PART II:

MINERAL RESOURCES ASSESSMENT, NATIONAL PETROLEUM RESERVE, ALASKA

* Interim Report

November 15, 1977

U.S. DEPARTMENT OF INTERIOR

Cecil D. Andrus, Secretary

U.S. BUREAU OF MINES

John D. Morgan, Acting Director

INTRODUCTION

The known mineral resources (other than oil and gas) within the NPRA are summarized in this report, and the results of the 1977 Bureau of Mines work are presented as an indication of the level of knowledge and activity concerning mineral resources in this area.

This report is intended to summarize the public knowledge of the mineralization in this area. This information is to be used for land use planning regarding the eventual disposition of the National Petroleum Reserve in Alaska (NPRA), as has been mandated by Congress under the National Petroleum Reserves Act of 1976. This mandate includes input from various agencies regarding resource values such as wildlife, cultural, scenic, etc., in addition to mineral values. The mineral resource inventory is covered under section 105(c) of this law.

In 1977 a joint program between the U.S. Bureau of Mines and the Geological Survey initiated mineral resource inventory - oriented field programs in the southern part of the NPRA, primarily restricted to the Paleozoic rocks south of the Colville River between west longitudes 156° and 162°. Geologic data were also collected in areas adjacent to the NPRA where geologic information was inferred to be pertinent to mineral resource evaluation of NPRA. The field work between the two agencies was assigned along the lines that field mapping and regional geochemical work would be done by the Geological Survey and the known or suspected mineralized areas would be investigated by the Bureau of Mines.

Recommendations for further mineral resource evaluation are presented, on the basis of having evaluated the known resource related information, together with identification of areas that need further field follow up, as well as identification of the types of work that would yield the most useful data. The work of the Geological Survey is summarized in Part I of this report.

Mineralization

Because of the inadequate level of geologic knowledge of the study area, as well as of the adjacent regions, any discussion of mineralization of potential resource significance must necessarily be somewhat generalized at this time. Presently known mineralization consists of several materials or categories of materials. These include coal, phosphate, radioactive minerals, oil shale, and metallic and non-metallic deposits. Aside from limited local use of some coal and oil shale for subsistence purposes, however, there has been no development or production of any minerals within the study area, nor have reserve estimations been attempted for any commodity other than coal, discussed below.

1. Coal

Approximately 60 percent of NPRA (fig. II-1) is underlain by Cretaceous sedimentary rocks in which coal is likely to occur. The distribution of these rocks has been fairly well documented by early exploration of the reserve for oil and gas. The rocks are gently warped under the Arctic coastal plain and moderately folded in the northern foothills region. Where coal has been found, its rank apparently corresponds to the amount of deformation the enclosing rocks have been subject to -- varying from subbituminous to bituminous with increasing deformation. A small amount of subbituminous coal was mined near Wainwright and at Meade River for local use during the 1940's.

Coal resources of the Arctic region were estimated by Barnes (1967) from data obtained by geologic surveys and oil test well drilling. Barnes departed from usual U.S.G.S. resource estimation procedure due to the scarcity of coal data. Consequently, his estimates include an undetermined magnitude of error and may requre major revision as more information becomes available. Table II-1 summarizes "identified" coal resources for NPRA calculated from information from only 80 outcrop and test well occurrences.

Hypothetical and speculative coal resource estimates for the Arctic region have been attempted by Tailleur and Brosge' (1975) and McGee and O'Connor (1975) from the same sparse data. These computations necessarily include an even greater error. No further attempt should be made to estimate hypothetical or speculative coal resources for NPRA until more data are made available.

1

COAL

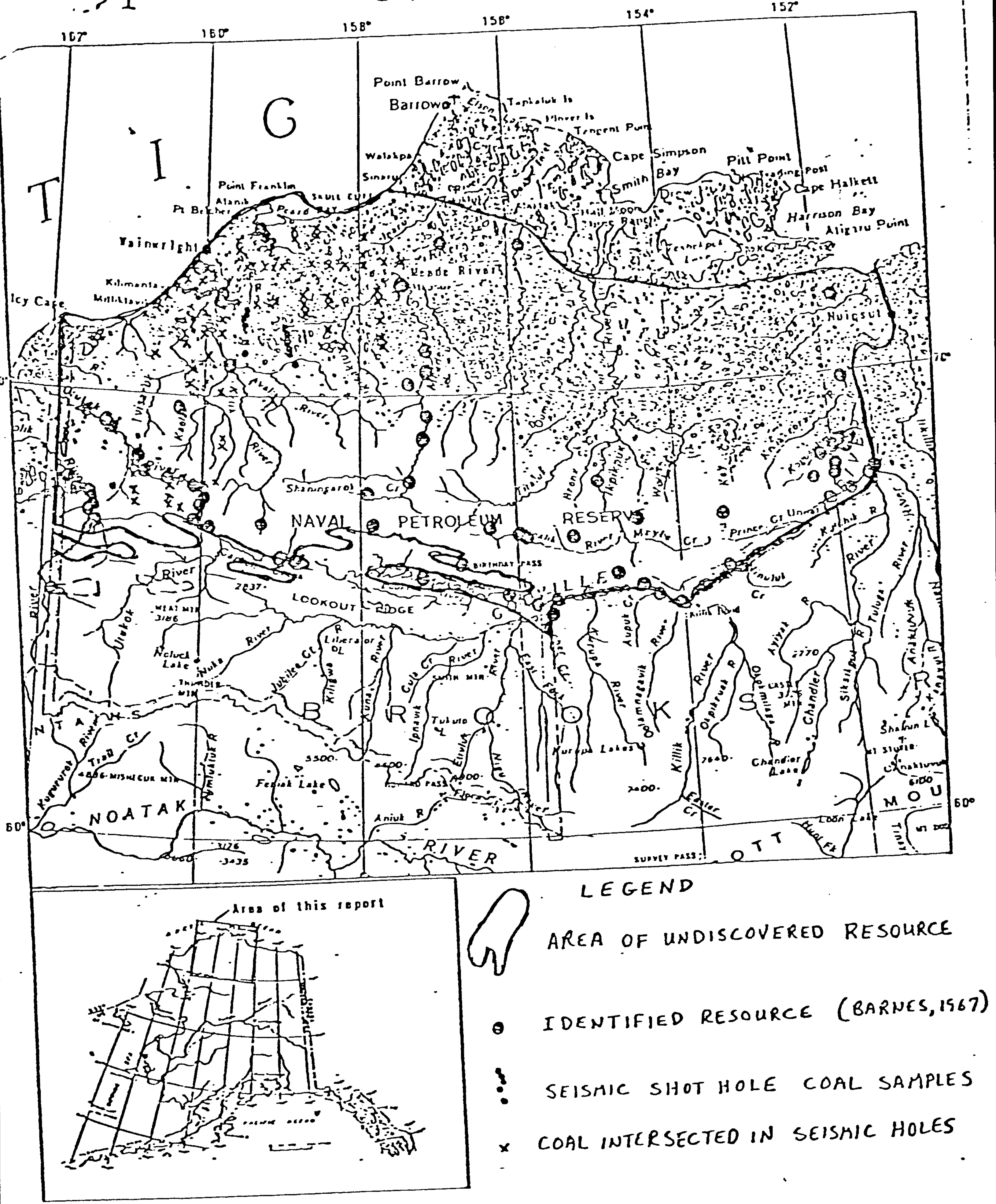


FIGURE II-1

TABLE II-1

IDENTIFIED COAL RESOURCES--NPR-A

(AFTER BARNES, 1967)

DISTRICT	Identified Resources (x 10^6 Short Tons)
BITUMINOUS COAL	
Kokolik River	2,336
Utokok River	2,738
Meade River	2,948
Colville River	4,896
Total Bituminous Coal	12,918
SUBBITUMINOUS COAL	
Utukok River	44,738
Kuk River	1,458
Kugrua River	840
Meade River	39,756
Ikpikpuk River	2,624
Colville River	7,726
Total Subbituminous Coal	97,142
Total Coal	110,060

The Navy and the U.S.G.S. have recently released coal samples obtained during seismic drilling in the reserve during the period 1974-1977. Samples from other seismic holes may become available in the near future. Locations and descriptions of those seismic holes intersecting coal-bearing strata in the reserve have been furnished by private contractors. Coal is present at depths of 100 feet or less (the depth of the seismic holes) over much of the area (fig. II-1). The Bureau of Mines is having these coal samples analyzed, in order to add to the data base in the region.

On the basis of data presently available, combined with conservative geologic projections, a very large resource of coal is indicated to be present within the boundaries of NPRA. However, there are serious questions with regard to the feasibility of ultimately utilizing much of this material, since a considerable proportion of the coal which has been examined to date occurs in thin layers, with perhaps prohibitively large amounts of interbedded and/or over lying rocks which contain little or no coal. A recent surface-mining feasibility study by a private engineering firm under contract to the U.S. Bureau of Mines summarizes the situation for the North Slope as a whole, as follows (Kaiser Engineers, 1977):

C. GEOLOGY AND COAL RESOURCES

The regional geology of western Arctic Alaska has been described by the United States Geologic Survey in reports by Brosge and Wittington (1966); Chapman and Sable (1960); Chapman, Detterman, and Mangus (1964); and Detterman, Bickel, and Gryre (1963). The coal resources of this area have been calculated by Barnes (1967).

1. Stratigraphy

Most of northern Alaska is underlain by Cretaccous sediments of both marine and nonmarine origin. Unconsolidated fluvial and marine alluvium of Quaternary age overlies the Cretaceous rocks throughout much of the region. Generally, the depth of unconsolidated material increases northward from the foothills of the Arctic mountains. Stratigraphic-type sections throughout the foothills province are shown in Figure 2-3. Coal-bearing areas of the North Slope that have been mapped by the U.S. Geologic Survey are illustrated in Figure 2-1.

2. Structure

The structure of northern Alaska is a series of east-west trending folds parallel to the front of the Arctic mountains. The degree of deformation and faulting decreases northward. The Arctic mountains are characterized by overturned folds and large-scale thrust faults. The southern foothills are characterized by isoclinal folds, thrusts faults and high-angle reverse faults. The northern foothills area contains simple folds with high-angle reverse faults occurring principally on anticlinal axes. The structure of the Arctic coastal plain is largely masked by alluvial deposits, and consists of gently undulating folds.

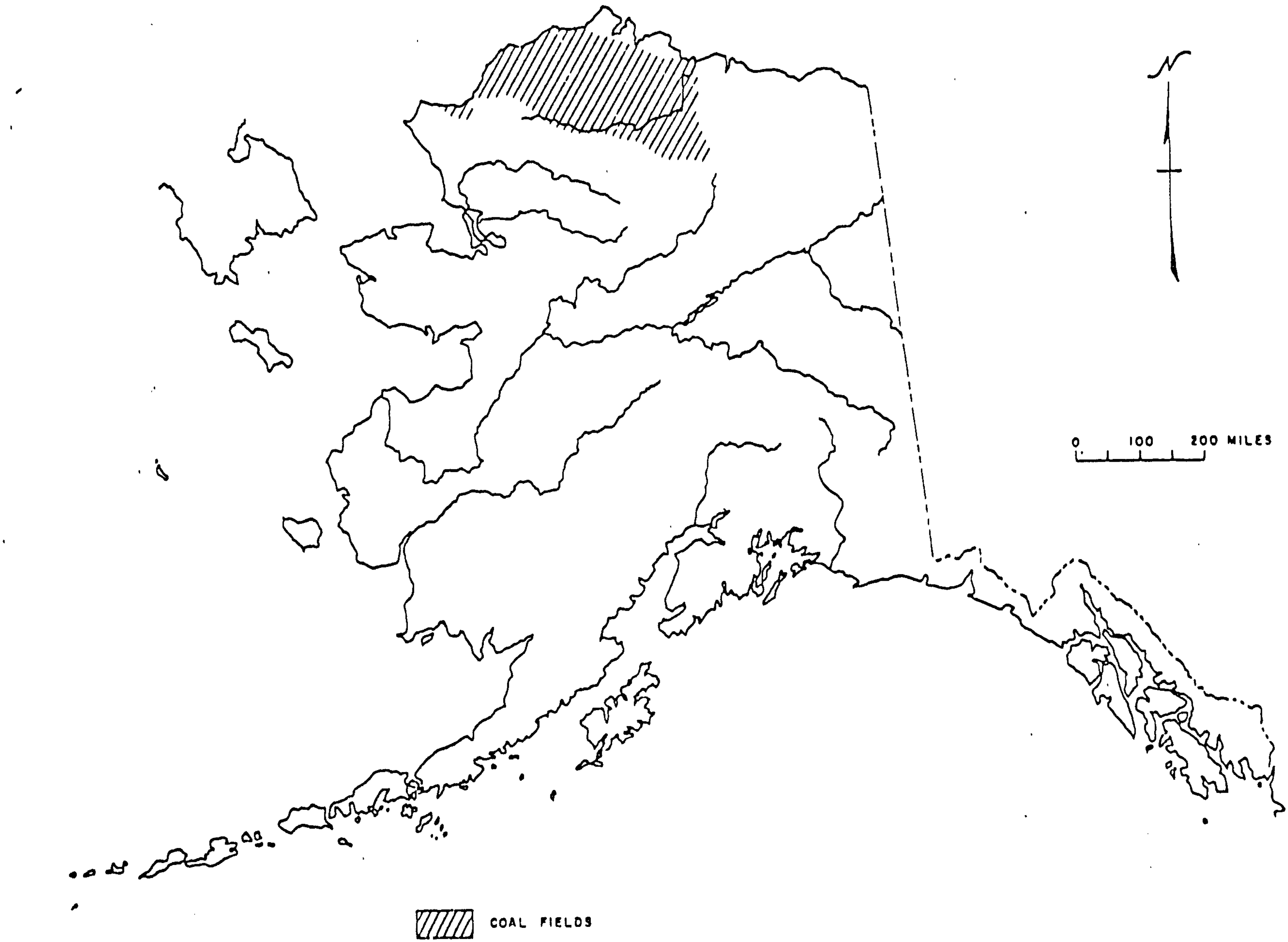
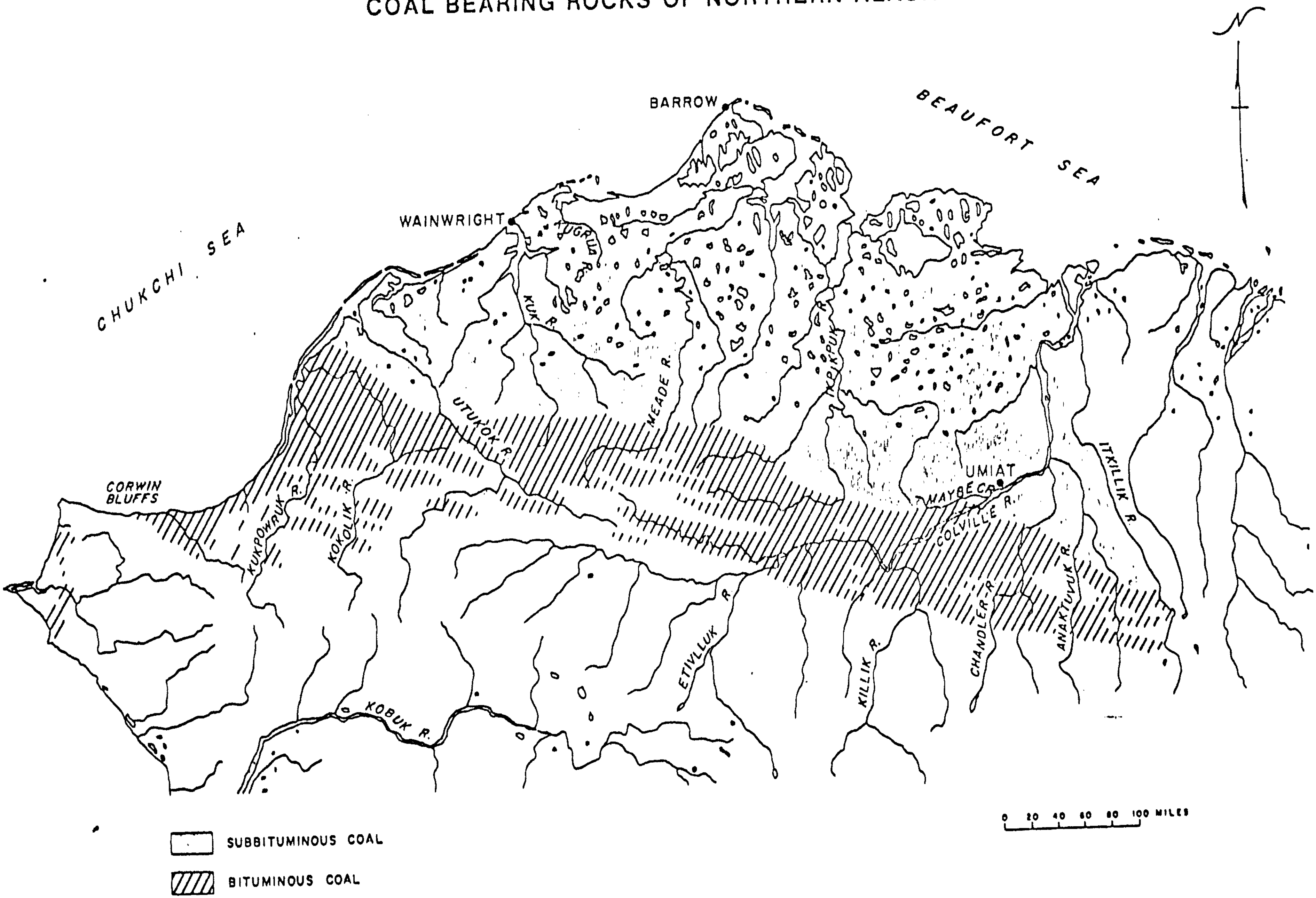


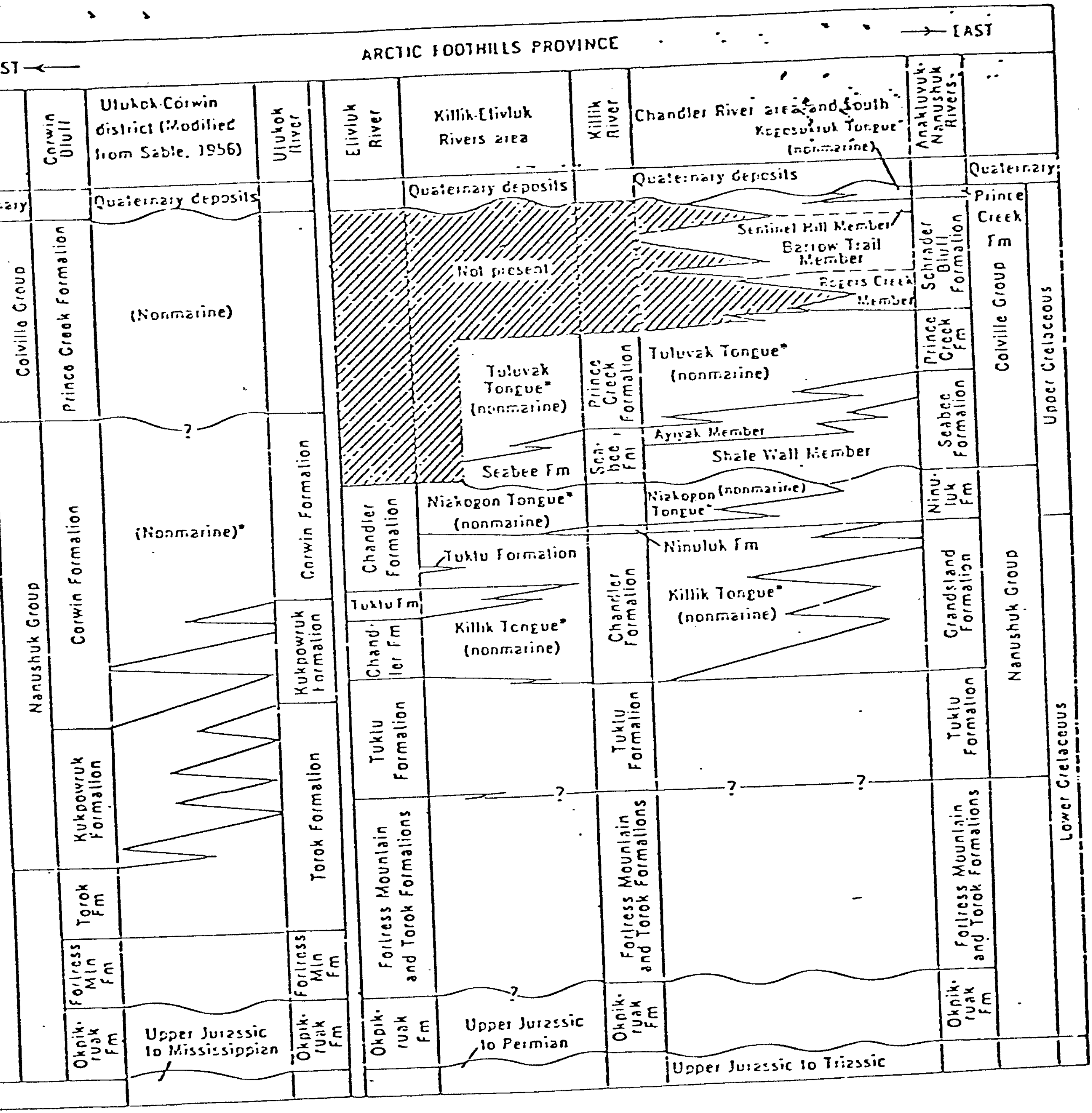
FIGURE 2 - 1

COAL FIELDS OF NORTHERN ALASKA

FIGURE 2-2

COAL BEARING ROCKS OF NORTHERN ALASKA





RINCIPAL COAL-BEARING UNITS

dified from Chapman and Others, 1954, Figure 62

FIGURE 2-3

STRATIGRAPHY OF NORTHERN ALASKA

Major mountain building took place during late Jurassic and early Cretaceous time. This was followed by two periods of folding. The first period of folding, which is considered more severe, occurred at mid-Cretaceous time. Additional folding took place during Tertiary time. The Brooks Range was probably caused by the Tertiary orogeny, which has little effect north of the southern foothills.

3. Coal Quality

The bulk of the coal in northern Alaska has been described as black and shiny with a blocky fracture. Some coal occurring in the Prince Creek Formation in the eastern portion of the region and in the Chandler Formation near the Arctic coast has been described as dull black with shaley fracture. Although few analyses have been performed, the bright blocky coal is generally bituminous and the dull shaley coal subbituminous. Barnes (1967) found that data on coal samples was often insufficiently complete to permit the assignment of rank according to ASTM standards. Therefore the rank assignments of the coal resources have often been made by considering the age and degree of deformation of the deposits rather than by using analytical data. The geographical distribution of bituminous and subbituminous coal is shown in Figure 2-2.

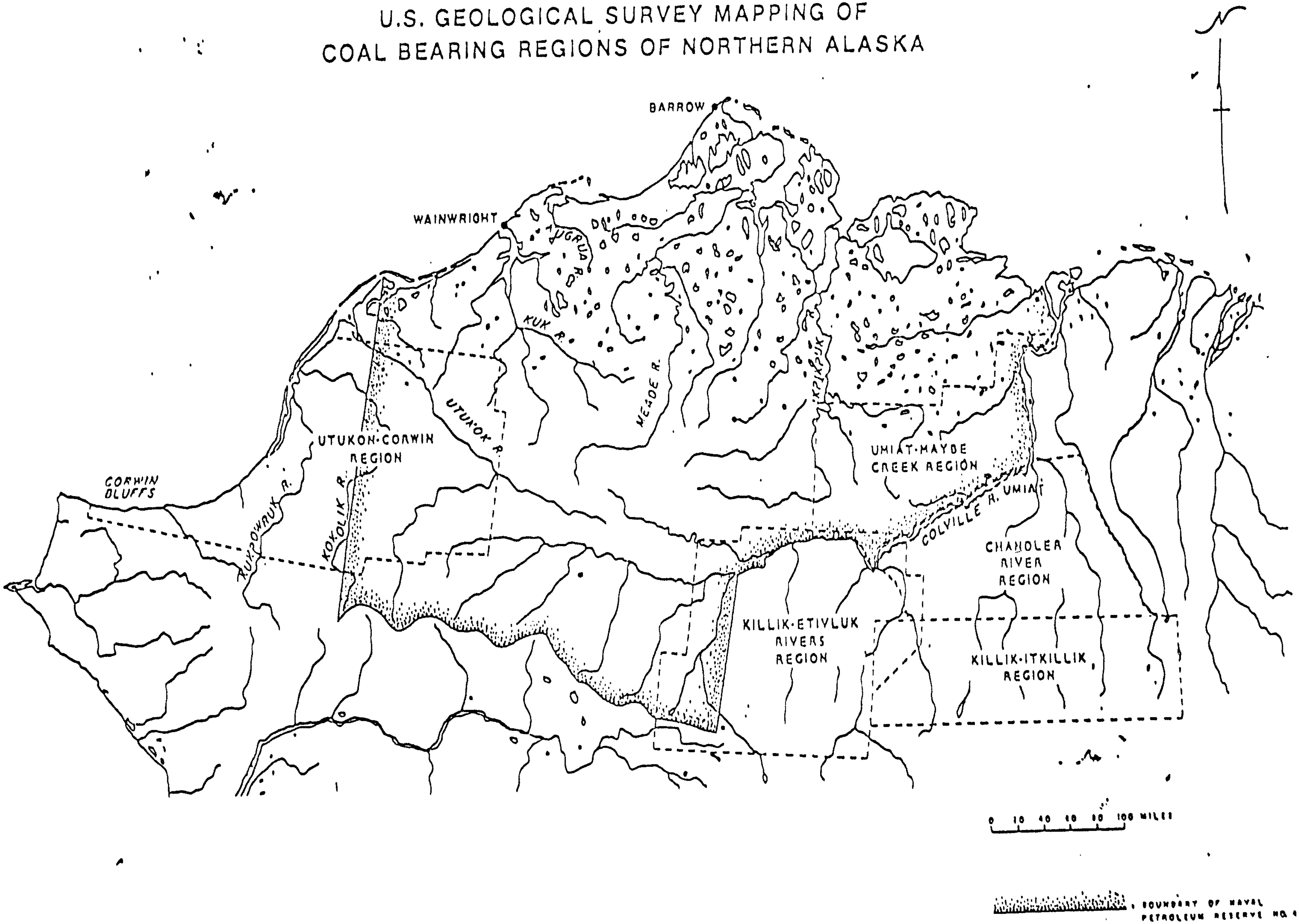
The rank of the coal is a function of age of deposition and degree of structural deformation. Younger and less-deformed coals tend to be of lower rank than older and strongly deformed coals. Therefore, the rank of coal in northern Alaska decreases northward from the southern limit of the northern foothills due to the fact that the degree of structural deformation decreases. In the eastern district, the rank of the coal decreases because younger sediments are exposed.

The youngest coal-bearing formation is the Prince Creek Formation which is of late Cretaceous age. This formation was deposited subsequent to the most severe period of structural deformation which occurred in the region. Therefore, Prince Creek coals, which are confined primarily to the eastern portion of the study area, are predominantly subbituminous in rank.

Coals of Middle Cretaceous age are found in the Nanushuk Group. These coals are bituminous in the folded rocks of the foothills, and subbituminous in the relatively undeformed strata of the coastal plain.

FIGURE 2-4

U.S. GEOLOGICAL SURVEY MAPPING OF COAL BEARING REGIONS OF NORTHERN ALASKA



Analyses of the coals from the Corwin Bluffs, Cape Beaufort, Deadfall Syncline, Kukpowruk River, and Kokolik-Elusive Creek areas have been described by Callahan and Sloan (1976). All of the coals analyzed occur in the western portion of northern Alaska in the Corwin Formation. The coals that were analyzed petrographically were of bituminous rank, predominantly "High Volatile B." The coals in the Kukpowruk area were generally higher in rank than those from the other areas, being borderline "High Volatile A-B." The Kukpowruk coals are stated to be "anomolously high" in quality. Coking tests have been performed on Kukpowruk and Cape Beaufort coals. The carbonization properties compare favorably with Sunnyside coal from Utah.

4. Coal Resources

Barnes (1967) calculated a total coal resource in northern Alaska of 120,197 million tons, consisting of 19,292 million tons of bituminous and 100,905 million tons of subbituminous coal. Resources were estimated to a depth of 3,000 feet. Bituminous seams in excess of 14-inch thickness and subbituminous seams greater than 30 inches thick were included in the resource estimate.

Several estimates have been made of strippable coal in northern Alaska. In 1971, the US Bureau of Mines estimated the "strippable reserves" of the region to be 478 million tons of bituminous coal and 3,387 million tons of subbituminous coal. Seam thickness criteria were the same as those employed by Barnes (1967). Coal reserves were estimated to a depth of overburden of 120 feet. The 1977 U.S. Bureau of Mines estimate of the "reserve base" of strippable coal in northern Alaska is 81.7 million tons of bituminous coal and 86.7 million tons of subbituminous coal.

The USGS and US Bureau of Mines (1976) have defined reserve base to be that portion of the Identified Coal Resource from which reserves are calculated. Reserves are that portion of the Identified Coal Resource that can be economically mined at the time of determination. Reserves are determined by applying a recovery factor to the reserve base.

In the calculation of the reserve base, the U.S. Bureau of Mines used a maximum cover depth of 120 feet and minimum seam thicknesses of 28 inches for bituminous coal and 60 inches for subbituminous coal. The coal resource estimate from which the reserve base was calculated was that of Barnes (1967).

(under contract to the U.S. Bureau of Mines)

Kaiser Engineers has independently developed an estimate of strippable demonstrated coal resources using the same calculation criteria and data as were employed by the U.S. Bureau of Mines. Kaiser Engineers' estimate is 81.7 million tons of bituminous coal and 60.5 million tons of subbituminous coal. The divergence between the U.S. Bureau of Mines and the Kaiser Engineers estimate of strippable subbituminous coal is due to Kaiser Engineers' exclusion of coal resources derived from test wells on Naval Petroleum Reserve No. 4. Barnes (1967) does not document how much of this coal was encountered in the upper 1,000 feet of the wells. Since other data below 1,000 feet of cover was not incorporated into the Kaiser Engineers estimate, the coal from the test wells was excluded. Also, the quality of the test well coal is questionable. It is possible that some of the material logged as coal is actually coaly shale.

Both the Kaiser Engineers and U.S. Bureau of Mines estimates of demonstrated strippable coal are significantly lower than previous estimates. The very small tonnages are indicative primarily of the degree of geologic assurance of the coal rather than the amount of coal that is thought to exist in northern Alaska. 96% of the bituminous and 98% of the subbituminous coal resources are in the "inferred" category and have not been incorporated into the reserve base. Also, considering the limited amount of coal exploration that has been conducted in northern Alaska, it is probable that many of the coal seams occurring in northern Alaska have not been observed in the field. In press releases, the U.S.G.S. has estimated potential coal resources of 4 trillion tons. These figures seem to be overly optimistic because they place heavy emphasis on cuttings from oil wells that could be carbonaceous shale. Nevertheless, there is no doubt that the estimate of northern Alaskan coal resources as calculated by Barnes (1967) is understated.

Because of the sparsity of exploration information, the reserve base of strippable coals is more realistically portrayed when inferred resources are included. Although the degree of geologic assurance of such a reserve base is low in comparison to that for other states, the lack of exploration makes it unlikely that this inventory is conservative from a statistical point of view. The inventory of bituminous coal with a minimum seam thickness of 28 inches is 868.3 million tons. The inventory of subbituminous coal with a minimum seam thickness of five feet is 1,040.4 million tons.

The reserve base represents an estimate of all coal in the ground meeting specific geometrical requirements (seam thickness and depth of cover), whether economically recoverable or not. Coal reserves are estimates of coal which can be recovered economically using current technology. Reserves are calculated by government agencies by applying recovery factors to the reserve base. This is a very simplistic approach and does not give adequate consideration to the economic aspect of reserve determination.

Implicit in the reserve determination techniques is the assumption that the cost of mining and transporting coal to market is essentially the same in northern Alaska coal field as in coal fields in other states. However, it is obvious that mining and transportation costs and capital amortization charges will be significantly higher in northern Alaska than elsewhere. The maximum volumetric stripping ratios which have been included in the reserve base for northern Alaska are 50.5 for bituminous coal and 23.0 for subbituminous coal.

To account for the high anticipated costs in northern Alaska, Kaiser Engineers recommends that the minimum thickness of seams to be incorporated into the reserve base be increased. It is recommended that minimum thicknesses should be 42 inches for bituminous coal and 10 feet for subbituminous coal. These thicknesses have been chosen because they are the thickest cutoffs employed by Barnes (1967). Obviously, seams thinner than the above can be effectively removed in multiseam operations which also contain thicker seams. The modified reserve base using the increased minimum seam thickness is presented in Table 2-1 and Figure 2-5. With a minimum seam thickness of 42 inches, the inventory of strippable bituminous coal is 553.8 million tons. The inventory of strippable subbituminous coal in seams greater than 10 feet is 205.1 million tons.

It must be emphasized that the strippable coal inventories for each area do not represent estimates of minable coal tonnages which occur in the various districts. There is a high degree of geologic uncertainty with respect to the existence of the coal, and recover factors have not been applied. The estimates do form, however, a statistical basis for ranking the relative potential of the coal-bearing districts, and represent a very rough approximation of order-of-magnitude in situ coal tonnages which may be amenable to surface mining.

TABLE 2-1

RESERVE BASE OF STRIPPABLE COAL IN NORTHERN ALASKA
(Demonstrated and Inferred Resources)
(Million Short Tons)

DISTRICT	BITUMINOUS COAL			SUBBITUMINOUS COAL		
	>28 in	>42 in	%>42 in	>5 ft	>10 ft	%>10 ft
Corwin Bluff-Cape Beaufort	17.8	12.1	68			
Kukpowruk R.	157.6	115.3	73			
Kokolik R.	112.3	88.9	79			
Utukok R.	142.4	134.9	95	121.4	89.7	74
Meade R.	146.9	145.5	99	135.9	0	0
Colville R.	291.3	57.1	20	546.0	0	0
Kuk R.				113.5	111.0	98
Kugrua R.				100.9	0	0
Ikpikpuk R.				22.7	4.4	20
TOTAL	868.3	553.8	64	1,040.4	205.1	20

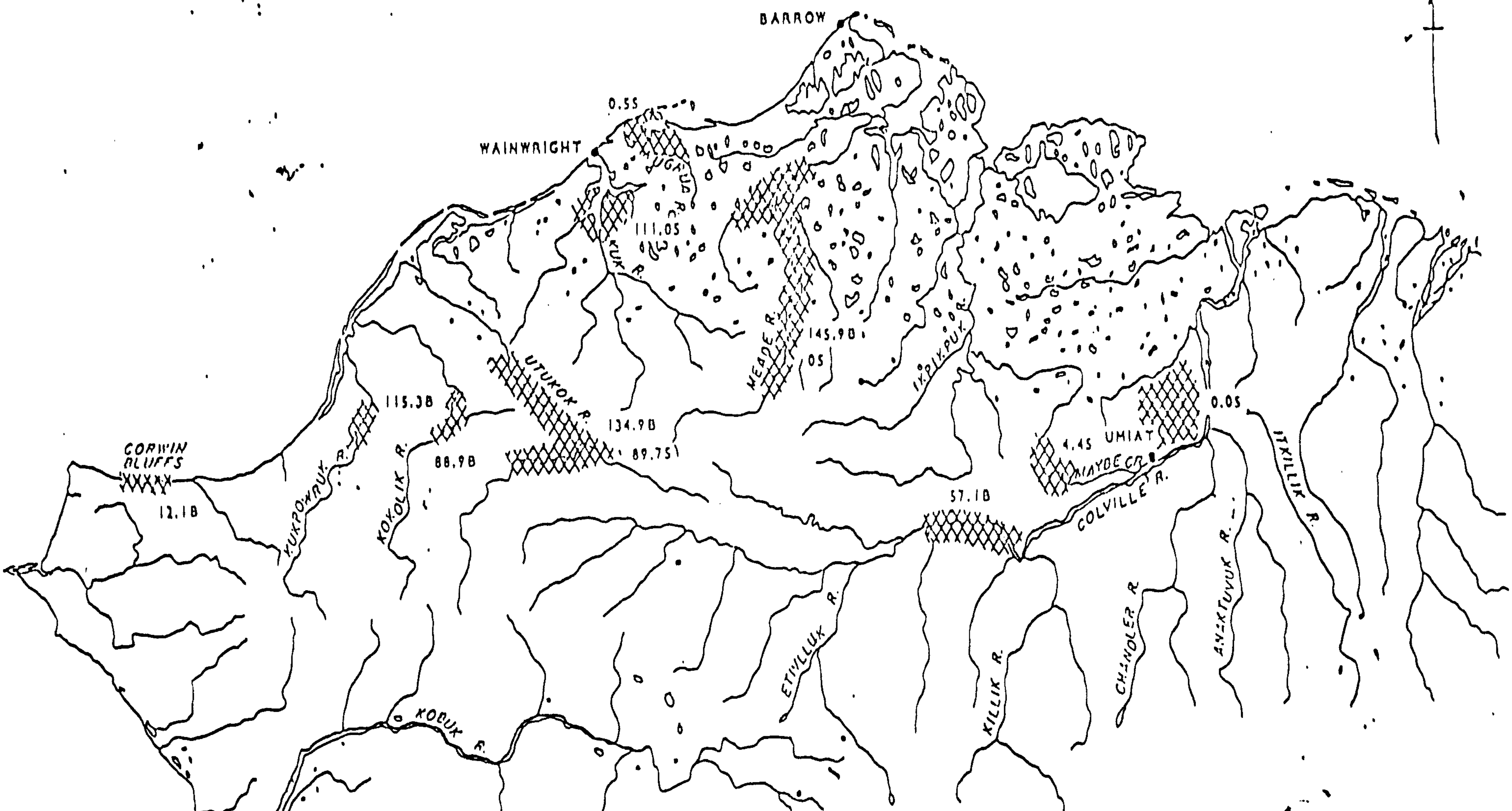
TABLE 2-2

RESERVE BASE OF STRIPPABLE COAL IN NORTHERN ALASKA
(Demonstrated Resources)
(Measured and Indicated Categories)

DISTRICT	BITUMINOUS COAL			SUBBITUMINOUS COAL		
	>28 in	>42 in	% >42 in	>5 ft	>10 in	> ft
Corwin Bluff-Cape Beaufort	3.7	2.6	71			
Kukpowruk R.	25.9	16.9	65			
Kokolik	10.6	9.3	88			
Utukok R.	9.4	8.3	89	7.4	2.5	34
Meade R.	11.6	10.1	87	4.1	0	0
Colville R.	20.5	5.9	29	31.9	0	0
Kuk R.				5.6	3.1	55
Kugrua R.				5.3	0	0
Ikpikpuk R.				6.2	4.4	71
TOTAL	81.7	53.1	65	60.5	10.0	17

FIGURE 2-5

STRIPPABLE RESERVE BASE OF NORTHERN ALASKA



0 20 40 60 80 100 MILES

B = BITUMINOUS COAL (MILLIONS OF TONS IN SEAMS THICKER THAN 42")

S = SUBBITUMINOUS COAL (MILLIONS OF TONS IN SEAMS THICKER THAN 10')

VIII. CONCLUSIONS AND RECOMMENDATIONS

The analysis of the technical and economic feasibility of surface mining northern Alaska has resulted in several conclusions. Based upon these conclusions, recommendations will be made concerning future work to be done regarding the surface mining of northern Alaskan coal deposits.

A. CONCLUSIONS

As a result of the investigation of the feasibility of surface mining the coal deposits, certain conclusions have been made:

1. Geology and Reserves

(a) The degree of exploration has not been sufficient to provide good estimates of demonstrated coal resources in coal-bearing areas of northern Alaska.

(b) Past estimates of strippable coal in northern Alaska are overstated.

(c) Coal in seams greater than 20 feet thick has not been identified to any great extent in northern Alaska. The exceptions are the 20-foot-thick Kukpowruk Seam and coal intersections of up to 30 feet in thickness which were encountered in test wells on Naval Petroleum Reserve No. 4. It is suspected much of the coal intersected by the test wells is carbonaceous shale. Generally, the coal seams encountered in northern Alaska are thinner than those encountered in other western states.

(d) Very little flat-lying coal exists in northern Alaska. Therefore coal reserves with less than 120 feet of overburden are limited.

(e) Given the geology and the costs of northern Alaska, most coal cannot be mined economically with current technology. Therefore, the criteria for calculating the reserve base in northern Alaska should be re-evaluated.

2. Environment and Reclamation

(a) The environment of northern Alaska is harsh. Special construction and equipment operating techniques will be required.

(b) The potential for success of reclamation projects in the Arctic is unknown.

(c) Insufficient data exists to make detailed environmental impact assessments of potential northern Alaskan mining activity.

3. Technical Feasibility

The coal deposits of northern Alaska could be mined with currently available equipment and mining techniques.

4. Economic Feasibility

(a) Currently identified demonstrated strippable coal resources are not economically minable. Therefore the strippable reserve of northern Alaska coal is 0 tons.

(b) The only potential minesite which showed economic promise was the Kukpowruk River coalfield. "Reserves" would have to be expanded by a factor of 10 before this coal would be competitive with existing coal sources.

B. RECOMMENDATIONS

Kaiser Engineers recommends, that no further work except for geological exploration be done until one of the following conditions is met:

- Demonstrated strippable resources for a coal deposit of more than 125 million tons at a stripping ratio of less than 5:1 are blocked out;
- Coal prices escalate at a rate which exceeds coal costs to the extent that existing demonstrated reserves become economic;
- A market for coal is found in the North Slope area.

It is tempting to make recommendations concerning equipment development, environmental baseline studies, reclamation studies, investigations of transportation systems, and sociological studies; however, presently known strippable coal deposits are not attractive enough to warrant any further work other than geologic exploration. When these studies are required, they should be done on a site-specific basis."

the Brooks Range, on a regional trend across northern Alaska. The localities noted to date (Figure II-2) in NPR-A were described as thin beds of phosphate rock or phosphatic (greater than 5, but less than 13.8 percent P_2O_5) mudstone, with grades of up to 24.8 percent P_2O_5. Table II-2 lists analytical data presently available. Rocks of the Shublik Formation of Triassic age have also been found to contain noteworthy concentrations of phosphatic materials elsewhere in northern Alaska, although, to date no such occurrences have been noted in Shublik rocks in NPR-A. However, no systematic explanation for phosphate rock is known to have been made in either of these rock units in NPR-A.

Data on hand indicate that nearly all of the phosphate rock evaluated thus far (Patton and Matzko, 1959) is of low or medium grade, although samples containing as much as 35.8 percent P_2O_5 have been found in the Shublik Formation in the eastern Brooks Range. However, it should be noted that, although the data are sparse, the northern Alaska phosphate rock samples also contain small amounts of uranium, probably in geochemical association with the phosphate-bearing mineral apatite, as well as perhaps with the dark-colored organic materials ubiquitous in these rocks. The uranium occurs in concentrations sufficient to suggest that it might represent a potentially valuable by-product. This, of course, would enhance the prospects regarding the feasibility of development of any phosphate resources which might be delineated.

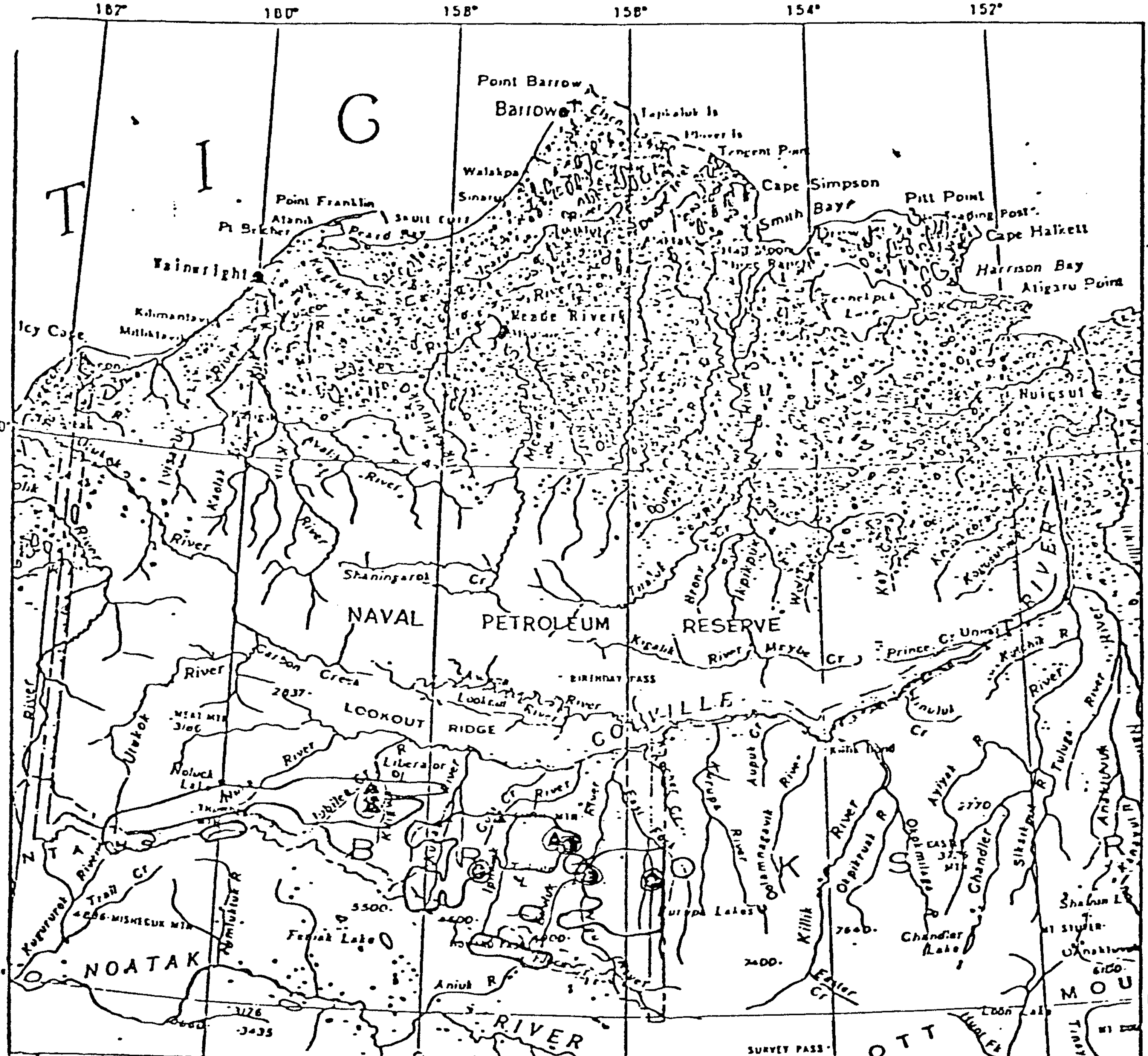
The phosphate rocks occur in close association with black cherts, shales-mudstones, and carbonate rocks, in an assemblage similar to those seen in some other important phosphate rock

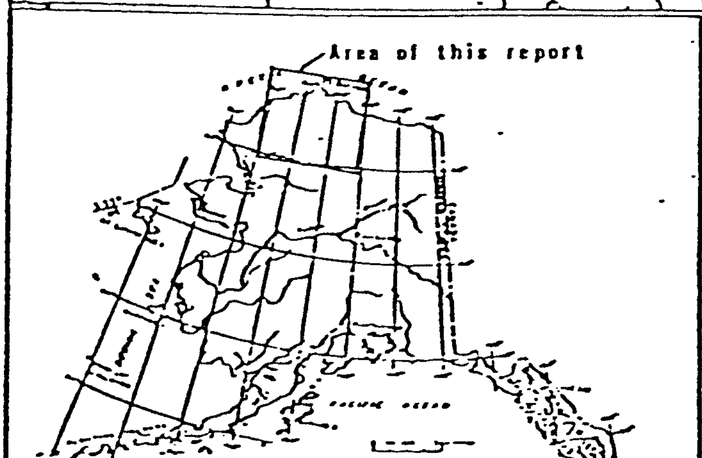
It should be emphasized that the foregoing represents an evaluation of surface-minable coal only, under present conditions of market value, infrastructure, and technology. Other aspects, as well as changing conditions, must also be considered, in order to assess the potential resource-base in a more complete manner.

2. Phosphate

Phosphate rock (rock which contains greater than 13.8 percent P_2O_5 by weight) occurrences have been described (Patton and Matzko, 1959) from horizons within the Lisburne group of Mississippian age along the north front and southern foothills regions of

PHOSPHATE AND OIL SHALE





LEGEND

PHOSPHATE OCCURRENCE (PATTON AND MATZKO, 1959)

OIL SHALE OCCURRENCE (TOURTELOT AND TAILLEUR, 1966)

AREA FAVORABLE FOR OIL SHALE (SELKREGG, 1975)

FIGURE II-2

deposits elsewhere. Thus, further exploration in NPR-A seems warranted, within those appropriate Lisburne and Shublik horizons where the geologic relationships suggest that similar sedimentary environments may well have existed during the original depositional regimes.

At the present time, data are insufficient to permit any estimate of resources within the study area. Further geologic and stratigraphic work, together with detailed examinations of known occurrences, will be required in order to improve this situation.

TABLE II-2

DATA FROM PATTON AND MATZKO, 1959

Sample No.	P_2O_5 (%)	U_2O_5 (%)	Equivalent U	Sample Description
50 ATr 61	24.8	0.17	0.008	Phosphate rock
50 AKt 89	< 5.0	-	< 0.001	Shale
50 ATr 99	< 5.0	-	0.001	Limestone
49 ALa 8	< 5.0	-	< 0.001	Limestone and mudstone
50 ATr 160	13.7	-	-	Phosphatic mudstone
51 ARr 126	< 5.0	-	0.002	Shale
51 ARr 134	< 5.0	-	< 0.001	Shale
51 ARr 111	< 5.0	-	< 0.001	Siltstone
51 ASa 36	0.2	-	0.002	Siltstone
50 ALa 257	< 5.0	-	< 0.001	Siltstone
49 ADt 41	5.0±	-	0.004	Mudstone

3. Radioactive Minerals

At present, little is known regarding the presence of such minerals in NPRA. The sedimentary rocks, particularly those which are of non-marine origin, should be considered as having decided potential with regard to occurrences of uranium, since rocks of similar depositional environments and post-depositional histories have proven to be favorable hosts elsewhere. Of paramount interest are the Cretaceous coal-bearing sedimentary sequences, with their associated sandstones and organic-rich rocks. A very large portion (at least 60 percent; see figure II-1) of NPRA is underlain by sedimentary rocks of this type, and, hence, must be considered as prospective for sedimentary uranium deposits, given our present lack of substantive data to the contrary.

Of additional concern are the possibilities of uranium more directly associated with coal itself, as well as with oil shales and phosphate rocks. These qualitative associations can be predicted with some assurance on geochemical grounds; the quantitative aspects can only be assessed by detailed investigation of the rocks themselves. The potential for other types of uranium deposits (veins, etc.) to exist within NPRA cannot be assessed at this time, given the inadequate geologic data base.

There are indications that some preliminary work along these lines has been done by several groups in the public and private sector, and attempts are being made to obtain further information from these groups for use in the present NPRA study.

4. Oil Shale

In addition to the interest in oil shales for their hydrocarbon content per se, attention has been devoted to the possibilities of extracting various metallic elements from rocks of this type. In this latter regard, it is known that preliminary examinations of selected oil shales from northern Alaska have been made by the private sector. Oil shales occur in several horizons in rocks ranging from Triassic to Middle Cretaceous age in the southern foothills of NPRA (fig. II-2). They have been described by Tailleur (1964) and Tourtelot and Tailleur (1965). The horizons lie in a structurally complex geologic setting, and more detailed geologic mapping is needed to clarify the extent and thicknesses of these rocks. In addition to the high content of organic matter, the samples reported by Tourtelot and Tailleur contained anomalous concentrations of a suite of heavy metals, including copper, cobalt, molybdenum, nickel, vanadium, and zinc in particular. Other elements with interestingly high levels of concentration were silver, gold, mercury, and arsenic. Table II-3 shows analytical data.

Should development of the oil shale ever become of interest, these associated concentrations of heavy metals might well be considered as potential by-products; any attempt to evaluate the resource potential of these metals themselves at the present time seems somewhat premature. However, a resource is definitely suggested here, although the magnitude cannot be assessed without more complete information regarding the extent of the oil shales, together with additional analytical data on the metals and their mode(s) of incorporation with the oil shale material.

TABLE II-3

ANALYSES OF METALS IN OIL SHALES FROM NORTHERN ALASKA-
DATA FROM TOURTELOT AND TAILLEUR, 1967

	SAMPLE						
Element	64ATr 209a	65ADl 270-1'	64ATr 210	65ADl 34	64ATr 208	64APa 208	G4ATr 305c
As	63	-	110	-	37	110	110
B	32	-	37	20	53	60	110
Co	8	-	14	-	2	12	27
Cr	18	20	16	150	24	48	250
Cu	8	50	25	100	38	34	480
Mo	110	50	450	30	110	440	100
Ni	22	15	72	20	22	28	400
Pb	< 10	-	< 10	10	10	< 10	10
Se	8	-	5	-	5	20	200
Sr	80	30	42	150	70	110	600
V	200	50	140	100	240	210	1700
Zn	48	-	38	-	38	34	7000
Hg (ppb)	1200	1200	1600	2200	1400	650	1500
Ag (ppb)	200	600	200	400	200	300	4000
Au (ppb)	50	100	100	200	< 30	70	50

(Values in ppm unless otherwise noted.)

5. Metallic and Related Non-Metallic Minerals

Noteworthy occurrences of materials in this general category have recently been reported in northern Alaska. Preliminary follow up work during the 1977 field season has resulted in recognition of significant zinc and lead (with associated silver values) mineralization along a fairly well delineated regional geologic trend of chert-shale-volcanic rocks of similar ages. This belt persists from the zinc-lead deposits in the DeLong Mountains quadrangle to the west (Red Dog Creek, Wulik River areas) east and across the southern portion of NPRA, including the most noteworthy showing found on NPRA to date, the Drenchwater Creek-Wager Creek area. Deposits of this type appear to have formed contemporaneously with volcanic activity (perhaps of a rather quiescent type) associated with a marine depositional environment as indicated by the chert-shale-volcanic rock association with the mineral occurrences. The entire region of NPRA in which this assemblage occurs must be considered as quite favorable for other similar deposits to exist. There is not enough data available at present to permit more than qualitative evaluations to be made with respect to resource potential, but all indications seem to suggest that considerably more effort is merited in endeavoring to define this resource within NPRA.

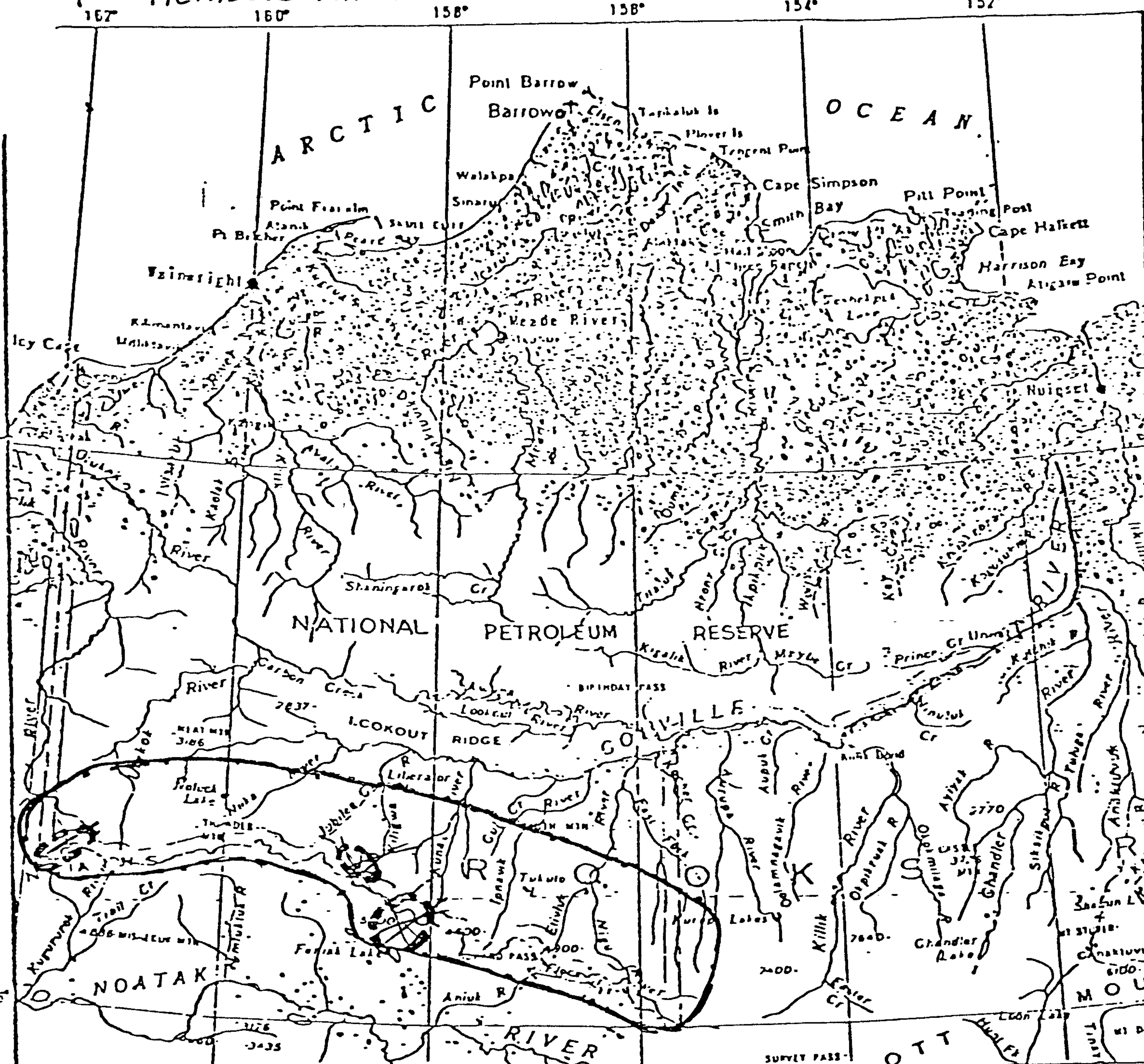
In the DeLong Mountains quadrangle, potentially valuable concentrations of barite are found associated with the zinc-lead deposits, but similar occurrences have not yet been noted within NPRA, although the rocks of interest regarding the zinc and lead do seem to be associated with anomalously high geochemical values for barium. This relationship suggests the possibility of finding barite deposits within NPRA as well. The fluorite occurrence at

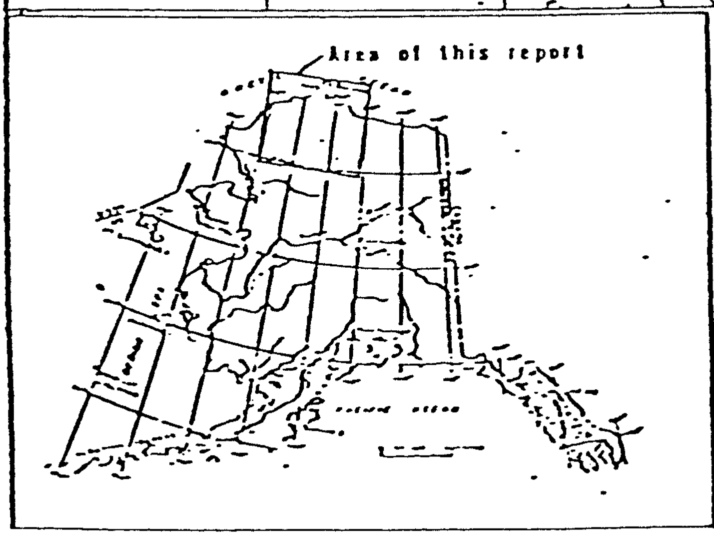
Mt. Bupto remains to be more thoroughly investigated, since fluorite is commonly found in close association with zinc, lead, and barium in chert-shale-carbonate rock-volcanic rock sequences elsewhere.

The igneous rocks found in the Siniktanneyak Mountain area are known to be of the type (gabbro, peridotite, dunite) commonly associated elsewhere with significant deposits of chromium, nickel, platinum group elements, and copper, as well as asbestos, talc, and jade. Geophysical data suggest extensions of these rocks onto NPRA along the southern border, which indicates a potential for resources of this type which should be investigated further.

The areas of interest for the materials in this general category are shown on Figure~~s~~ II-3.

+ METALLIC MINERALS





National Petroleum Reserve in Alaska-- NPRA

LEGEND

AREA OF GEOCHEMICAL ANOMALY

AREA OF INVESTIGATION BY U.S.G.S. AND BUREAU OF MINES PERSONNEL -- F.Y. 1977

FIGURE II-3

RECOMMENDATIONS FOR FUTURE WORK

It is deemed essential that considerably more work be done in order to obtain the geologic data base requisite to endeavoring to evaluate the mineral resources potential of NPR-A in a meaningful manner. At the present time the level of geologic knowledge is sufficient only to suggest the distinct likelihood that such additional work should result in elucidation of a significant resource base within the region, probably encompassing several types of commodities. The recommended program should entail extensive and intensive field and laboratory studies, carried out by professional groups with expertise and experience in the appropriate aspects of geology, geochemistry, geophysics, and minerals engineering. A suggested general format for this work program would be somewhat as follows:

I. General Approach

A. Regional reconnaissance work

1. Geologic mapping and geochemical study.
2. Emphasis on areas, trends, belts of known geology which are suspected to be particularly favorable for mineralization, e.g., Lisburne group cherts and shales;
   volcanic/volcaniclastic sequences;
   mafic/ultramafic associations;
   Shublik Formation;
   non-marine sedimentary rocks, etc.
3. Search for, and elucidation of, "stain zones" of oxidizing sulphide minerals, which may represent significant mineralization localities.

4. Field investigation of areas in which "anomalous" geochemical values have been discerned by regional geochemical studies.
5. Field investigation of areas of interest outlined by means of various geophysical surveys (airborne magnetometer, radiometric, etc.).

B. Detailed follow-up work, as appropriate.

1. Geologic mapping.
2. Sampling - rocks, stream sediments, soils - for chemical, mineralogic, petrographic, other analysis and study.
3. Geophysical surveys.
4. Drilling to elucidate relationships at depth, as warranted.

C. Ongoing evaluation of sample materials already on hand, or available from other sources.

1. Chemical, mineralogic, petrographic, other analysis and study, as appropriate.

D. Evaluation of data in light of mineral resource values.

More specifically, for the types of mineralization presently recognized, the work program recommended for the foreseeable future is as follows:

<u>Coal</u> -

is required

A concerted effort to carry out field mapping, as well as geophysical and exploratory drilling work, at a scale sufficient to result in a valid and meaningful assessment of the quality and quantity of the coal resources of NPR-A. In lieu of a project of this scope, the presently available inadequate data base will continue to provide "estimates" of questionable value. Continuing analysis of such coal samples as are made available from any and all other sources (e.g., the seismic shot holes, and new test wells) will result in additions to this data base, but this is hardly a viable substitute for a systematic coal resource evaluation program.

Metallic and associated non-metallic resources - Included here for consideration are elements such as zinc, lead, silver, copper, nickel, chromium, and the platinum group, as well as barite and fluorite. These have been found in significant concentrations within the study area and immediate environs; concentrations of other metallic and non-metallic elements may well remain to be discovered here as well.

The recommended work program would continue regional reconnaissance studies, as outlined previously. Attention should focus initially on rock assemblages of the chert-shale±-volcanics association, particularly in the Lisburne group trend. Other areas of interest, in particular, "stain zones" as well as areas of geochemical "anomalies" also should be investigated. The mafic/ultramafic rock associations along the southern border of NPR-A are of concern as well, since regional geophysical work indicates extensions into NPR-A.

Detailed follow-up work, of the type outlined previously, should be done in the Drenchwater-Wager Creek area, as well as along the northern margin of the Siniktanneyak pluton, and further work in the Mt. Bupto area seems called for. Additionally, such other areas of interest as may be discovered during the course of the program would be followed up in similar fashion, as appropriate.

Phosphate rock -

Regional reconnaissance across NPR-A, in the appropriate geologic environments, is needed in order to outline areas of occurrence. This work should be focussed primarily on rock units known to contain significant amounts of phosphate elsewhere in northern Alaska. The regional stream sediment geochemistry data might be a useful guide in this work, as well as such airborne radiometric data as may become available from other sources. As appropriate, detailed follow-up would be required to further delineate areas of potential resource interest.

Radioactive minerals -

Regional reconnaissance, based on airborne radiometric data (as such becomes available) as well as on stream sediment geochemical data, should be carried out across the study area. Radiometric scanning of rock samples on hand from the oil and gas test well drilling activity, together with additional chemical, mineralogic, petrographic, and other analytical work, also should be pursued. Additional field mapping and sampling, with similar analytical work, should be done, in order to achieve a thorough assessment of those (coal-bearing Cretaceous, in particular) sedimentary rocks believed to be of such aspect as to represent potential hosts for accumulations of uranium mineralization within NPR-A.

In addition to the recognition of uranium mineralization per se, studies of this sort must be carried out in order to detect, evaluate, and trace the movement(s) of geochemical "fronts" related to the transportation and deposition of uranium and associated elements within the host rocks and associated subsurface fluids. It has been amply demonstrated elsewhere that only in this manner will a meaningful assessment of a sedimentary basin be possible. Without this degree of study, the decidedly favorable sedimentary sequences within NPRA will remain unknown quantities with regard to their content of radioactive energy minerals. Analysis of other materials studied during the NPRA work (coal, oil shale, phosphate rock, etc.) should also be performed routinely.

Oil shale -

Those stratigraphic units known to contain oil-shale materials should be mapped and sampled, on a regional basis, with detailed follow-up as appropriate, in order to assess their potential value as sources of various metals. Regional stream sediment geochemical data should provide useful guidance in this work. Analysis of samples from all other sources should be an integral part of this effort as well, since presumably the primary concern in much of the other work is with the hydrocarbon content, not necessarily the metalliferous content of the samples.

Miscellaneous non-metallics -

In lieu of a specific program component focussing on such materials, an attempt should be made to maintain an awareness of, and watch for, materials of potential interest, such as bentonite, kaolin clays, etc., within the context of the other work.

U. S. BUREAU OF MINES NPR-A 1977

FIELD INVESTIGATIONS

Summary

The 1977 U. S. Bureau of Mines mineral resource evaluation program of the National Petroleum Reserve-Alaska (NPRA) was limited to 12 field days. Support in the field was provided by sharing U. S. Geological Survey camp facilities at the Driftwood airstrip. A Bell 206B Jet Ranger, under contract to Evergreen Helicopters, was used for transport from camp to areas of interest. Camp support from Kotzebue was expedited by Maxson Aviation, Inc. ~~- primarily using their Twin Beech B 8 Turboprop aircraft~~ Flight time to camp from Kotzebue was about 45 minutes (cost $360/hr.).

Weather conditions were excellent during the entire field season and no lost time was recorded for this reason.

The Bureau party consisted of three professional people, on each of two field sessions. The Bureau's program as originally designed was to: first, in June, investigate known or reported showings; and later, in July, make use of U. S. Geological Survey's 1977 regional geochemical studies' data to identify areas for additional follow-up. This plan had to be modified when, at the end of the first phase, it was learned that geochemical results would not be available until September. The new plan was to sample known "color" anomalies - those due to oxidation of pyrite in chert. This alternative was not wholly satisfactory, but, other than going back and sampling oil shales and exploring for phosphate

horizons, little else appeared to be left to do until the regional geochemical data became available. ~~Fortunately,~~ However, on revisiting the Drenchwater Creek area, and during the attempt to follow out known minor mineralization and zones that were thought to be geochemically anomalous, a sulfide-bearing float zone of 200 feet X 200 feet was discovered near the center of an area which had recently been mapped in some detail, ~~by a U.S.G.S. party.~~ ~~These sulfides had not been found at the time of this earlier mapping.~~ This ~~"stratiform"~~ apparently stratabound sulfide zone presented a new mineralized horizon which could be explored for additional concentrations of base metal sulfide mineralization. Several days of prospecting along the mapped outcrops and color anomalies led to the location of several zones of sulfides and boxworks. Some of these contained readily recognizable galena crystals. This second zone of mineralization is located about 4,000 feet to the east of the previously mapped zone of sulfides, in the same "stratigraphic" horizon as the main sulfide showing.

In the NPRA, eighteen separate zones or areas were prospected or examined. Only the Drenchwater Creek area was found to contain obvious base metal sulfides in or near outcrop. This exploration target zone is 7,000 feet to possibly 10,000 feet long, and includes two stratigraphic horizons which are known to contain base metal mineralization. These are the black shales, "underlying" the volcanics, in which a 2 foot sphalerite bed, or lens, or "concretion", contained 230,000 ppm zinc (or about 23% zinc). These black shales also contained geochemically highly anomalous lead. The second zone of mineralization, containing the "semi-massive" sulfides, appears to be confined at or near the top of a thin, south dipping acid volcanic sequence, which is several hundred feet stratigraphically higher than the black shales.

The eighteen areas examined, and surface materials recognized, are:

	Site/Location	Surface materials of potential interest	Notes
1.	Upper Kagvik Creek	Pyritic chert	1976 USGS geochemical data, high Ba with chert
2.	Ilingnorak Ridge	Fe oxides	Cretaceous(?) or younger rocks
3.	Elbow Creek	Pyritic chert	Color anomaly
4.	Chertchip Creek	Pyritic chert, black shale	Color anomaly black shale below pyrite, as at Drenchwater
5.	Rampart, Recon, Jubilee Creeks	Pyrite, Fe oxides	Pyritic dark gray chert
6.	Drenchwater Creek	Pb, Zn sulfides	Two mineralized zones known
6a.	Upper False Wager Creek	Pyritic chert	Color anomaly
7.	Kiligwa River	Pyritic chert	Color anomaly
8.	Boundary (d)(2)-NPRA	Fe	Fe oxides in creek north of Siniktanneyak Mountain
9.	Cutaway Creek	Pyritic chert	Shublik Fm., pyrite in cherts, "petroliferous" rock
10.	Lisburne Ridge	Phosphate	Phosphate not found; little time spent here
11.	Mt. Bupto	Fluorite	Reported fluorite, minor amounts found
12.	Safari Creek I	Ba	Siksikpuk Formation, barite nodules
13.	Safari Creek II	Pyrite	Kayak Formation, pyrite "concretions"
14.	Siniktanneyak Mtn.	Chrome +	Layered(?) ultramafic rocks, up to 21% Cr in bands up to 8 inches thick

15.	Spike Creek	Pyrite	Pyrite in chert, same stratigraphic sequence as at Red Dog
16. & 17.	Utukok and Kokolik Rivers	Coal	Helicopter recon of previously reported coal localities; none found
18.	Rolling Pin Creek	Pyrite with chert	Color anomaly

* Shublik Formation - (Triassic) has phosphate in beds up to 30 feet containing ~~18.7%~~ 34.5% P_2O_5 in Arctic National Wildlife Range.

Details of 1977 Work

The following sections provide additional information on the areas investigated. Localities are keyed by number to the overlays, Figs. BM A, B.

1. Upper Kagvik Creek - Misheguk Mountain Quadrangle

   Color anomalies in area are due to oxidizing pyrite in cherts of Siksikpuk(?) Formation. Geochemical reconnaissance by U.S. Geological Survey in this area indicated anomalous barium and minor, possibly anomalous, zinc. This area was selected for initial detail sampling because the color anomalies occur in a strike valley northeast from the Red Dog, the color anomalies (i.e., pyritic chert units) being in the bottom of the topographic "low". The local geology appears to be complex, possibly repeating the formation by tight folding.

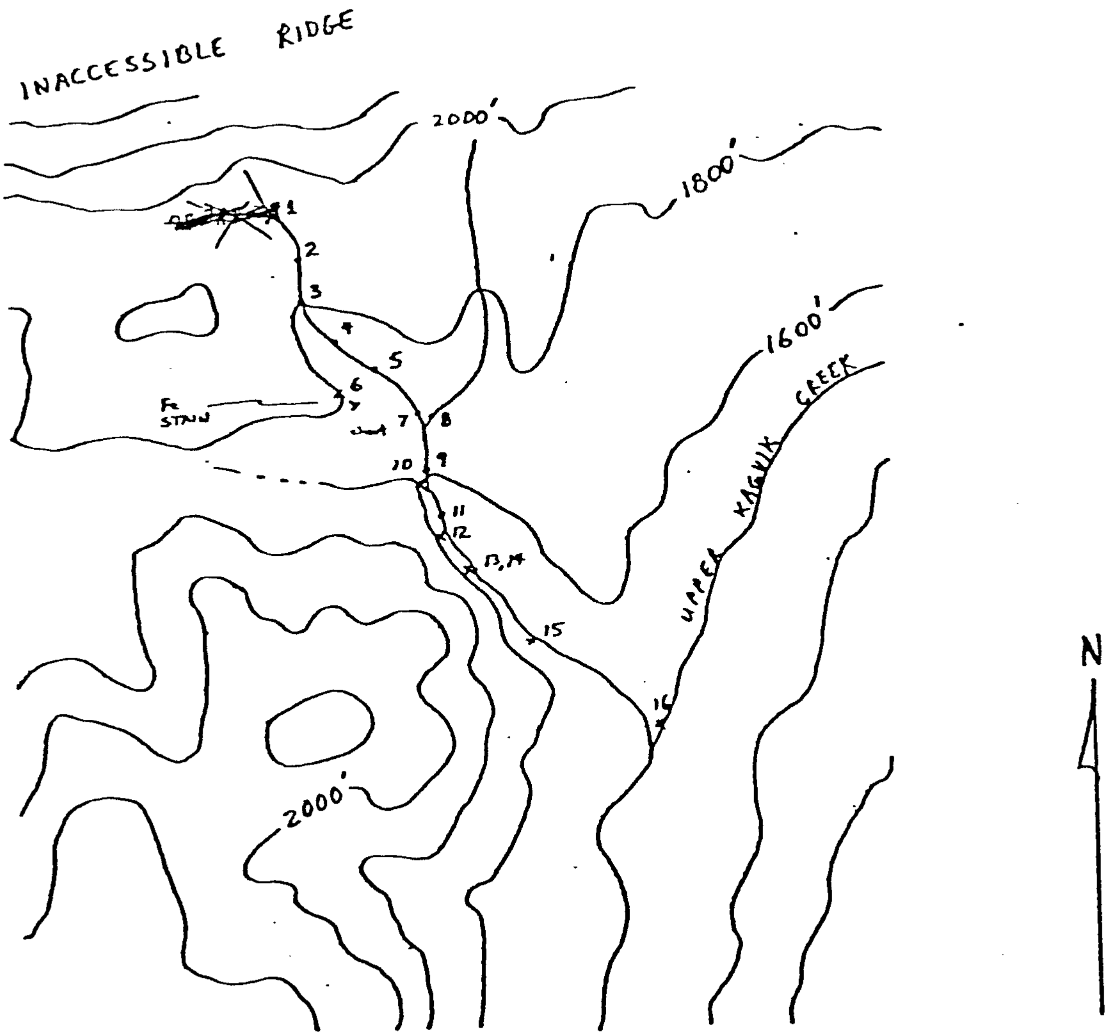
   Two creeks that cut across the strike of the rock units, as well as two color anomalies were sampled at close spaced sample intervals, in order to obtain an indication of any possible sources of metals. Several of the color anomalies were chip sampled, with individual chip channels not longer than 100 feet.

   Sample sites and sample numbers are shown on Figures BM 1, 2, 3, and analytical results are shown on Tables BM-1, 2.

UPPER KAGUIK CK

6-13-77
BAGGS

AREA SOUTH OF INACCESSIBLE RIDGE

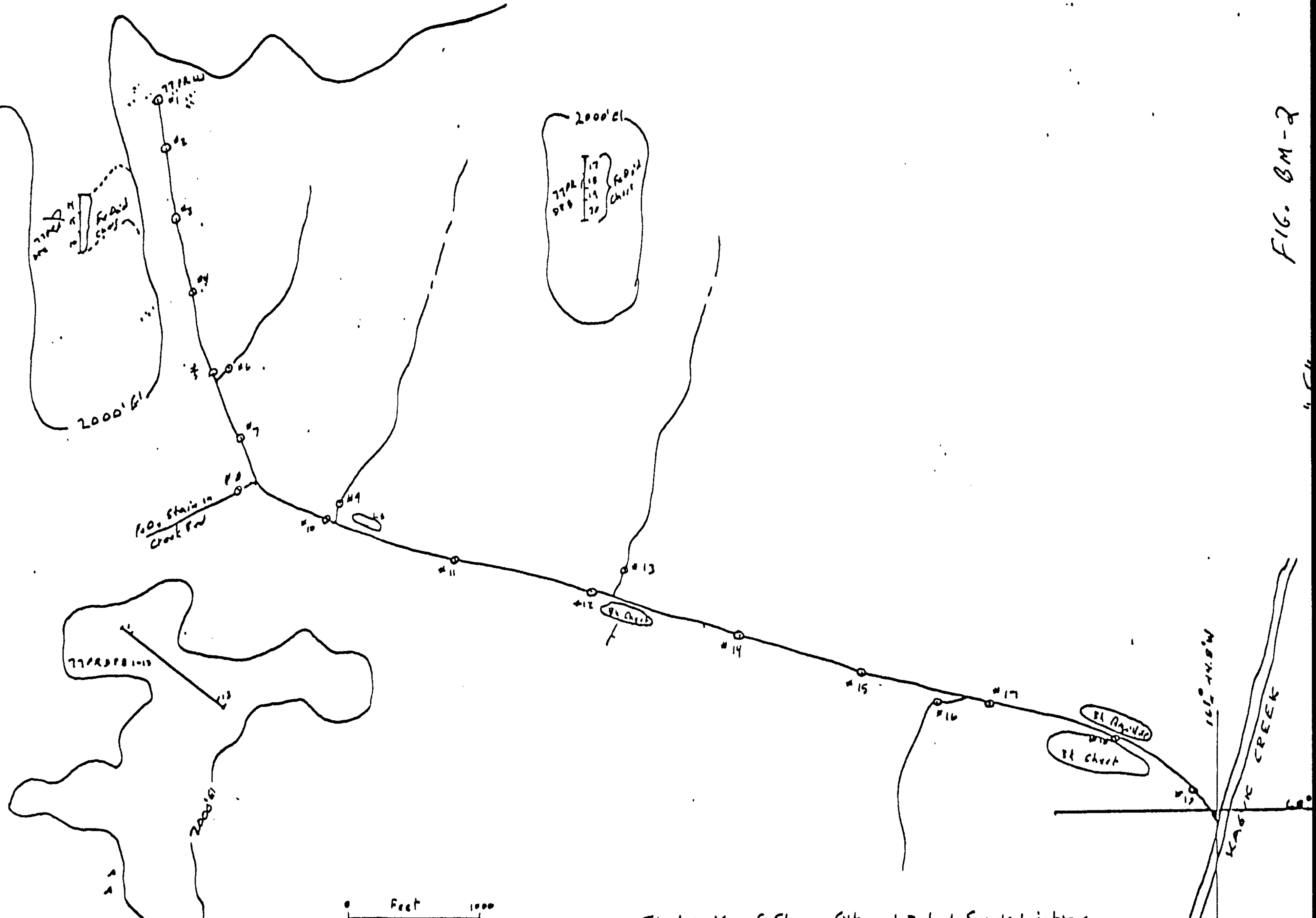


(Samples "77PRDWB...")

≈1000'
scale

FIG. BM-1

FIG. BM-2



Sketch Map of Stream Silt and Bedrock Sample Locations

Kagvik Creek Area, Inaccessible Ridge

Misheguk Mountain Quad, Alaska

T 11 S R 41 W UMIAT B&M

For U.S. Bureau of Mines

UPPER KAGVIK CK

6-12-77

BAGGS

AREA S.W. OF INACCESSIBLE RIDGE

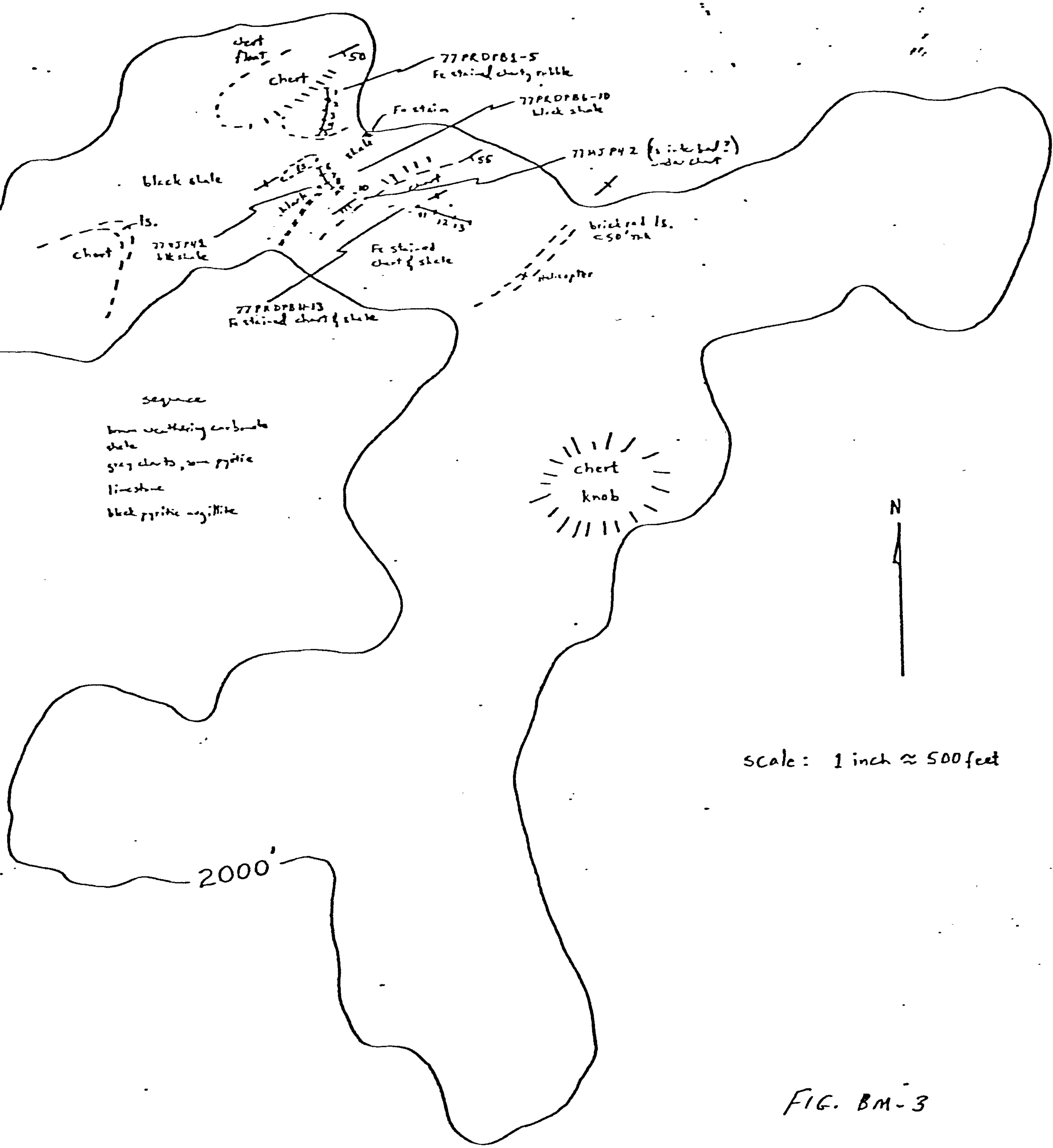


FIG. BM-3

TABLE BM-1

Locality: UPPER KAGVIK CREEK - MISHEGUK MOUNTAIN QUADRANGLE

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRDWB 1	80	45	175	Stream silt
2	45	30	135	Stream silt
3	70	35	140	Stream silt
4	50	35	115	Stream silt
5	55	35	120	Stream silt
6	55	5	30	Chert
7	70	35	145	Stream silt
8	90	40	135	Stream silt
9	75	35	140	Stream silt
10	55	25	215	Stream silt
11	80	35	185	Stream silt
12	25	5	20	Brown chert
13	70	35	170	Stream silt
14	105	15	215	Black shale
15	60	< 5	25	Pyritiferous chert
77 PRUJ 1	125	20	270	Stream silt
2	130	20	310	Stream silt
3	145	20	205	Stream silt
4	140	20	160	Stream silt
5	120	15	310	Stream silt
6	150	20	255	Stream silt
7	145	15	365	Stream silt

TABLE BM-1 (continued)

Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
	Elements Analyzed			
77 PRUJ 8	90	25	165	Stream silt
9	85	20	215	Stream silt
10	130	20	470	Stream silt
11	120	15	390	Stream silt
12	105	15	370	Stream silt
13	105	25	215	Stream silt
14	105	15	340	Stream silt
15	105	20	340	Stream silt
16	50	25	155	Stream silt
17	80	15	310	Stream silt
18	80	15	280	Stream silt
19	55	25	160	Stream silt
20	5	85	5	Black shale
77 PRDPB 1	30	10	95	Light grey chert
2	55	5	500	Light grey chert
3	55	5	120	Grey siliceous mudstone
4	45	5	90	Grey siliceous mudstone
5	35	5	75	Grey chert
6	15	10	40	Dark grey-black mudstone
7	5	10	20	Black carbonaceous mudstone
8	5	5	40	Black carbonaceous mudstone
9	5	5	35	Black shale-mudstone
10	35	5	105	Black shale-mudstone

TABLE BM-1 (continued)

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRDPB 11	25	5	20	Grey siliceous mudstone
12	55	5	30	Grey siliceous mudstone
13	45	5	80	Grey siliceous mudstone
14	60	5	40	Grey siliceous mudstone
15	50	5	65	Grey siliceous mudstone
16	70	5	70	Grey chert
17	45	5	80	Grey chert
18	55	5	55	Grey chert
19	65	5	35	Grey mudstone
20	65	5	50	Grey siliceous mudstone
21	45	5	100	Grey siliceous mudstone

TABLE BM-2

Locality: UPPER KAGVIK CREEK - MISHEGUK MOUNTAIN QUADRANGLE

Element	Sample Number 77PRDPB-1	Sample Number 77PRDPB-9	Sample Number 77PRDPB-13	Sample Number 77PRDPB-16	Sample Number 77PRDPB-21
Fe	1%	1%	2%	1%	2%
Ca	.05%	.7%	.02%	.02%	.02%
Mg	.15%	.15%	.2%	.15%	.2%
Ag	1	1	< 1	< 1	< 1
As	< 500	< 500	< 500	< 500	< 500
B	30	30	20	20	20
Ba	5,000	1,000	5,000	10,000	10,000
Be	< 2	< 2	< 2	< 2	< 2
Bi	< 10	< 10	< 10	< 10	< 10
Cd	< 50	< 50	< 50	< 50	< 50
Co	< 5	< 5	< 5	< 5	< 5
Cr	100	150	70	70	70
Cu	50	10	50	50	50
Ga	< 10	< 10	< 10	< 10	< 10
Ge	< 20	< 20	< 20	< 20	< 20
La	30	30	20	20	20
Mn	15	20	200	500	100
Mo	2	2	< 2	< 2	< 2
Nb	20	20	< 20	< 20	< 20
Ni	15	15	20	15	20
Pb	15	10	10	< 10	< 10
Sb	< 100	< 100	< 100	< 100	< 100
Sc	10	< 10	10	10	10
Sn	< 10	< 10	< 10	< 10	< 10
Sr	50	70	50	50	100
Ti	1,500	1,000	1,000	500	1,000
V	100	100	50	50	50
W	< 50	< 50	< 50	< 50	< 50
Y	20	10	10	< 10	10
Zn	< 200	< 200	< 200	< 200	< 200
Zr	50	50	50	30	50

TABLE BM-2 (continued)

Element	Sample Number 77PRDWB-6	Sample Number 77PRDWB-12	Sample Number 77PRDWB-14	Sample Number 77PRDWB-15	Sample Number 77UJPR4-2
Fe	1%	.7%	3%	1%	.2%
Ca	.15%	.02%	.07%	.03%	> 20%
Mg	.15%	.1%	.2%	.1%	1%
Ag	< 1	< 1	< 1	< 1	< 1
As	< 500	< 500	< 500	< 500	< 500
B	20	20	30	15	10
Ba	10,000	2,000	10,000	>10,000	500
Be	< 2	< 2	< 2	< 2	< 2
Bi	< 10	< 10	< 10	< 10	< 10
Cd	< 50	< 50	< 50	< 50	< 50
Co	< 5	5	15	< 5	< 5
Cr	50	100	50	70	30
Cu	50	20	100	50	5
Ga	< 10	< 10	10	< 10	< 10
Ge	< 20	< 20	< 20	< 20	< 20
La	30	30	20	30	20
Mn	3,000	70	1,000	700	700
Mo	2	2	< 2	< 2	< 2
Nb	< 20	< 20	< 20	< 20	< 20
Ni	15	20	100	10	10
Pb	< 10	< 10	< 10	< 10	10
Sb	< 100	< 100	< 100	< 100	< 100
Sc	15	10	20	15	< 10
Sn	< 10	< 10	< 10	< 10	< 10
Sr	70	50	150	200	1,000
Ti	700	500	2,000	500	200
V	70	50	70	20	20
W	< 50	< 50	< 50	< 50	< 50
Y	20	10	20	< 10	10
Zn	< 200	< 200	200	< 200	< 200
Zr	50	50	70	50	20

2. <u>Ilingnorak Ridge</u> - Misheguk Mountain Quadrangle

Red weathering zones on this ridge were noted while on helicopter trips to investigate other reported areas of mineralization. While the rocks appeared to have the aspect of Cretaceous sediments, a field check was made nevertheless. These color anomalies, which have very limited surface extent, are confined to a carbonate cemented greywacke - impure sandstone, and they are due to hematite which cements some of the sand grains. Samples were not taken.

A later investigation of similar rock units by U. S. Geological Survey Oil and Gas Conservation Division geologists (Tom Ahlbrandt group) found minor specularite in greywacke.

3. <u>Elbow Creek</u> - Misheguk Mountain Quadrangle

The first day spent prospecting in the NPRA proper, following the examination of the Upper Kagvik Creek area, was concentrated on efforts to determine if strike extensions of pyritic cherts extend into the NPRA from the sampled site. This reconnaissance work was done by helicopter, flying to the northeast on strike projection of the known rock units.

An area of color anomalies similar to those at Upper Kagvik was located 25 miles to the northeast. Examination of the rocks show that both dark gray, brown weathering chert (with one speck of malachite) and light gray "tuffaceous" chert and pyritic chert are present. Within the tuffaceous appearing unit a thin (1 foot - 2 feet) zone of bedded pyrite in tuff was located and sampled.

Analytical results are given in Tables BM-3, 4.

TABLE BM-3

Locality: ELBOW CREEK - MISHEGUK MOUNTAIN QUADRANGLE

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRUJ 20	5	< 5	50	Chert
21	125	5	285	Grey siliceous mudstone

TABLE BM-4

Locality: ELBOW CREEK - MISHEGUK MOUNTAIN QUADRANGLE

Element	Sample Number 77PRUJ-21	Sample Type
Fe	3%	Rock, banded siliceous (tuff?) chert with pyrite
Ca	.07%	
Mg	.5%	
Ag	< 1	
As	< 500	
B	20	
Ba	10,000	
Be	< 2	
Bi	< 10	
Cd	< 50	
Co	20	
Cr	30	
Cu	100	
Ga	10	
Ge	< 20	
La	20	
Mn	500	
Mo	2	
Nb	20	
Ni	50	
Pb	10	
Sb	< 100	
Sc	20	
Sn	< 10	
Sr	150	
Ti	3,000	
V	100	
W	< 50	
Y	15	
Zn	200	
Zr	70	

(Values in ppm unless otherwise noted.)

4. Chertchip Creek - Misheguk Mountain Quadrangle

Oxidation of iron due to weathered pyrite, in gray chert, forms a striking isolated color anomaly near the headwaters of Chertchip Creek. This area was recommended by I. Tailleur for possible field follow-up because of its similarity with anomalies at the Red Dog and Drenchwater prospects, as well as other areas of pyritic cherts in the northern Brooks Range and NPRA.

A field investigation was made of the pyritic light gray chert. An aerial helicopter reconnaissance of the area also indicated the presence of black (graphitic) shales in a tributary to Chertchip Creek. The previous experience at Drenchwater Creek showed anomalous base metal concentrations and a concretion or thin 2 foot bed of sphalerite in a similar setting, and therefore these black shales and siliceous mudstones were sampled for geochemical analysis to determine if any anomalous base metal concentrations are present.

Analytical results are [illegible] BM-5.

TABLE BM-5

Locality: CHERTCHIP CREEK - MISHEGUK MOUNTAIN QUADRANGLE

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRDWB 21	5	5	10	Black shale
21-A	10	< 5	20	Siliceous py. nodule in black shale
22	30	< 5	15	Pyritic grey chert
23	45	5	20	Pyritic grey chert
24	10	< 5	20	Grey siliceous argillite
25	5	< 5	20	Black shale
26	30	< 5	50	Pyritic black siliceous mudstone
27	25	< 5	75	Mudstone and black py. chert
28	50	5	95	Pyrit. black chert and mudstone
29	10	5	15	Black shale
30	5	< 5	5	Black siliceous mudstone
31	15	< 5	15	Black siliceous mudstone
32	15	< 5	30	High grade Fe stain zone; dolo.
33	25	15	265	Concretion; dolo.

5. Rampart, Recon, Jubilee Creeks - Howard Pass Quadrangle

Bright red iron oxide stained zones occur along much of the length of a creek between Recon and Rampart Creeks, both tributaries to Jubilee Creek from the east. This area is to the west and approximately on strike from the known sulfide mineralization at Drenchwater Creek. Because of similar color anomalies spatially associated with the mineralization at Drenchwater, a field investigation of color anomalies was undertaken here, even though it was not known if the rock units are of the same age and formation at both localities.

Two chip channel samples were taken to represent the chert stratigraphic section. Only pyrite was noted in the chert.

This chert unit is "tough" and resistant to weathering, and controls the stream channel location to a large extent.

A stream silt sample was taken for chemical analysis to determine if any base metal values are entering the stream above the area of the chip channel sampling.

The chip channel samples were taken a short distance (200 feet - 400 feet) upstream from the area of the confluence of the unnamed creek and Jubilee Creek.

Analytical results are given in Table BM-6.

TABLE BM-6

Locality: RAMPART, RECON, JUBILEE CREEKS - HOWARD PASS QUADRANGLE

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRUJ 106-A	30	45	110	Black pyritic chert
106-B	30	5	35	Black pyritic chert
107	95	15	190	Stream silt
108	30	5	30	Black py. chert; strat. above 106

6. Drenchwater Creek - Howard Pass Quadrangle

Interest in the Drenchwater Creek area resulted from verbal reports from the U. S. Geological Survey that geochemically anomalous base metal and barium values were obtained in samples collected in this area in 1975. While the metal values were sufficiently high to warrant follow-up, the most anomalous values were for barium rather than base metals. The discovery was in red-yellow weathering pyritic cherts.

A subsequent revisit to this area by the U. S. Geological Survey, with minor prospecting, led to the discovery of a 2 foot bed of sphalerite in black shales which apparently underlie the pyritic volcanic derived cherts.

With this information in hand, it was decided to do detailed sampling of all "stratigraphic" units along Drenchwater Creek near the mineralized zone. This work showed that the general stratigraphic sequence from top to bottom is:

Dark gray siliceous mudstone;
Pyritic tuffs and fragmental tuffs;
Carbonate cemented tuffs;
Gray cherts - pyritic, minor PbS, ZnS;
Black graphitic shales and mudstones.

The original "soil" samples were from the units between the shale and mudstone, i.e., the materials overlying the volcanic unit were the horizons sampled.

Later visits to the area were made to examine areas of reported "felsites" and volcanics, as well as a group of outlined but unmapped (unidentified) units on several ridges immediately to the east of the Drenchwater Creek showings.

When the Bureau of Mines party returned for the July work on the NPRA it was found that the U. S. Geological Survey had a group of 6(?) people mapping this area in detail (1:20,000). This mapping and sampling was for petrographic and other work. Nevertheless, it was decided to prospect the eastward strike extensions of the black shale and pyritic chert units from Drenchwater Creek.

While doing this a brown stained creek bed was noted and followed to determine the source of the iron in the creek. At first it appeared that the staining might be coming from a swampy area, but on closer examination it was seen that the source of the brown (iron) stain was from a "rubble" outcrop to the north of the small swampy area. Prospecting of this area led to the recognition of abundant "gossan" and boxworks that represented leached sulfides. Further prospecting then led to the discovery of sphalerite and galena, interlayered within the volcanic rocks. This mineralization is present at the top of the volcanic sequence, and is closely associated with the overlying siliceous mudstone.

The discovery of this second zone of sulfides presented another stratigraphic horizon for exploration. While tracing this horizon to the east several zones of pyrite float were found. Approximately 4,000 feet to the east a zone of galena-bearing boxworks were discovered and sampled. Further prospecting did not lead to the discovery of additional signs of mineralization to the east of False Wager Creek.

The volcanic units are present in the area from False Wager to Wager Creek. Outcrop is sparse in the area where the mineralized unit would be anticipated to occur. A soil geochemical survey might be used to advantage in this area if the mineralized horizon carries through here.

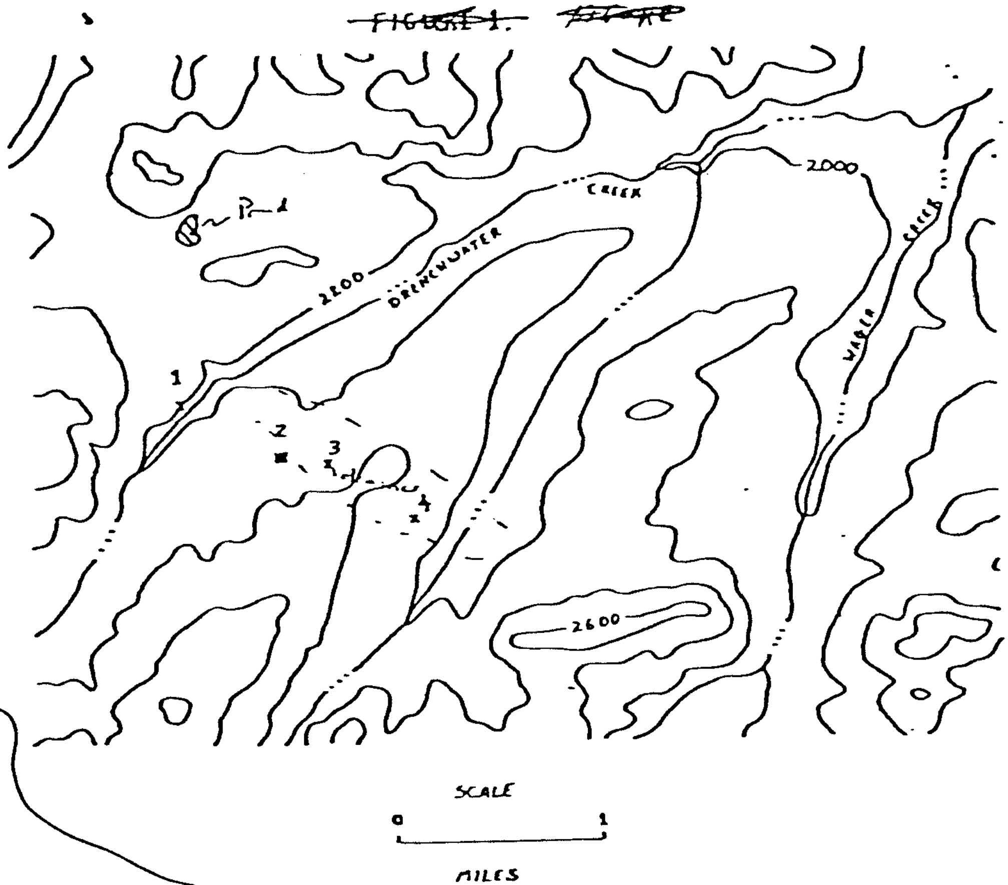
The current interpretation by the U. S. Geological Survey shows that the rocks east of Wager Creek are different in age from those mineralized at Drenchwater Creek.

Figures BM-4 - 9 show localities sampled, as well as various aspects of geologic relationships relevant to the mineralization in this area.

Analytical results are given in Tables BM-7 - 10.

Lat Long of Map Showing

DRENCHWATER CREEK
SULFIDE OCCURRENCES - 1977

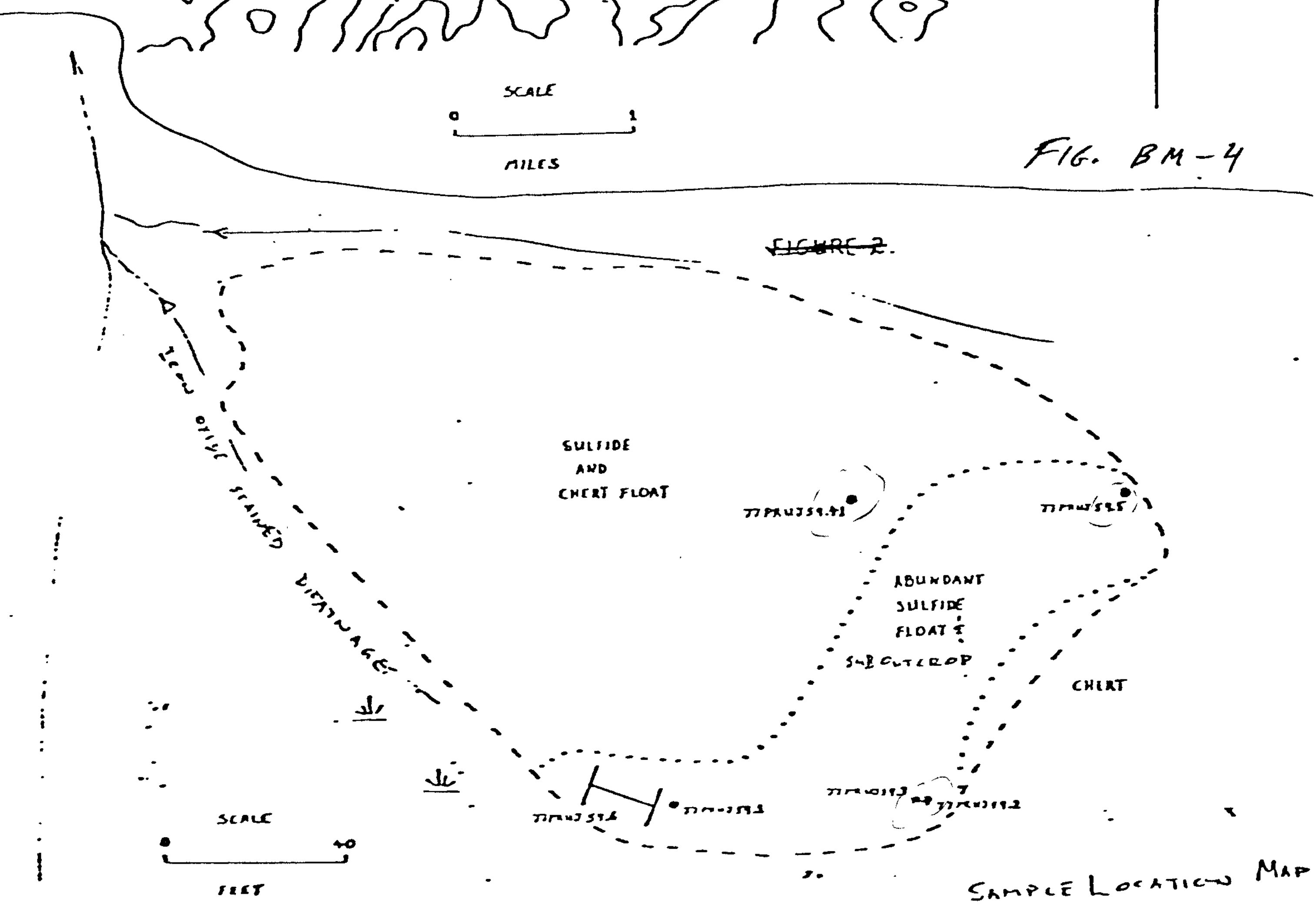


EXPLANATION:

1. SPHALERITE OCCURRENCE
2. AREA OF ~~FIGURE 2~~ BM-5
3. IRON-STAINED BOXWORK
4. BOXWORK WITH MINOR GALENA
   Sample 77FRW365

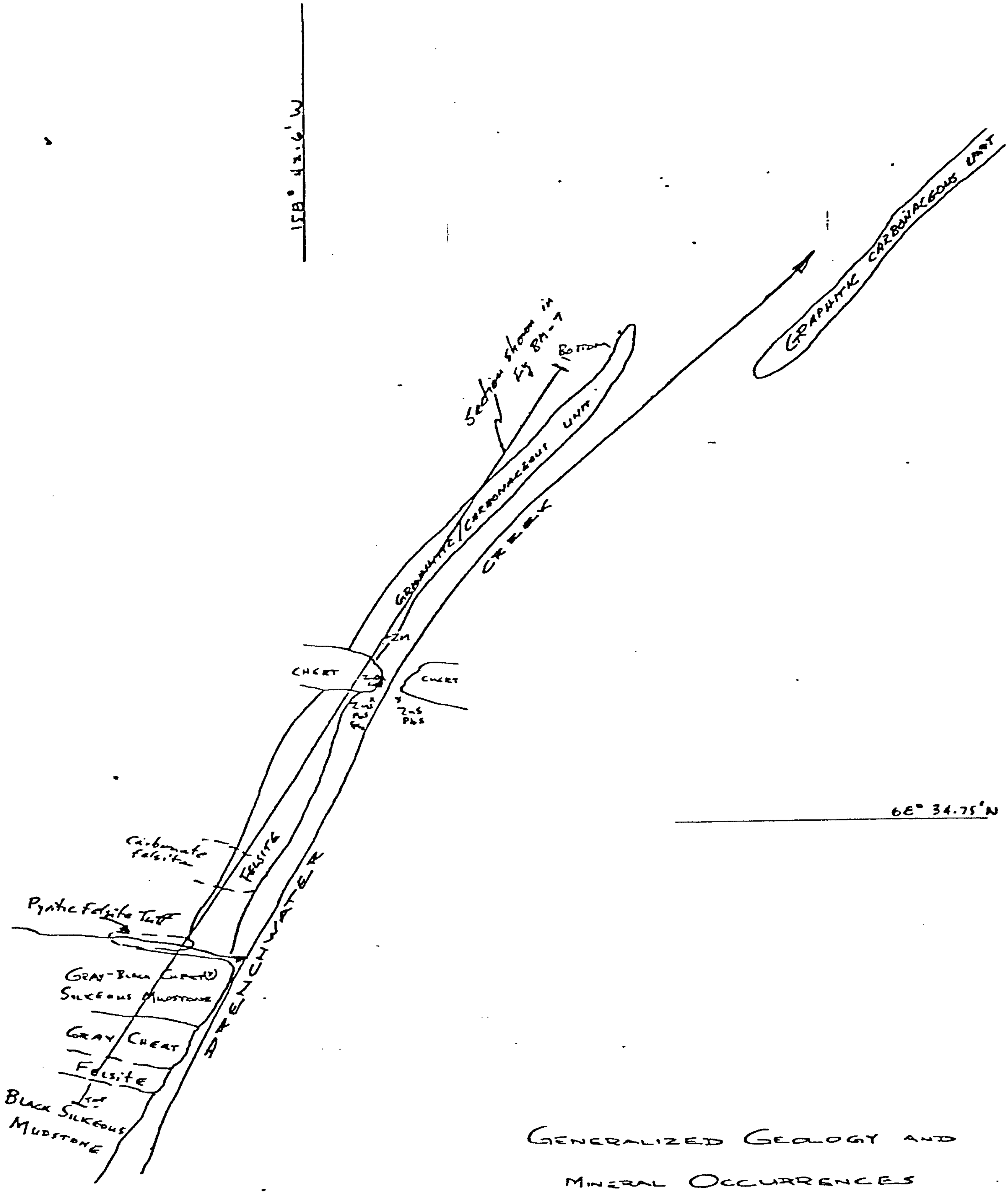
N

FIG. BM-4



Sample Location Map
Sulfides

FIG. BM-5



Generalized Geology and Mineral Occurrences

Drenchwater Creek Area

Howard Pass Quad NPRA

Schematic Presentation of Relative Unit Thicknesses

UJ. 10/1977

Fig BM-6

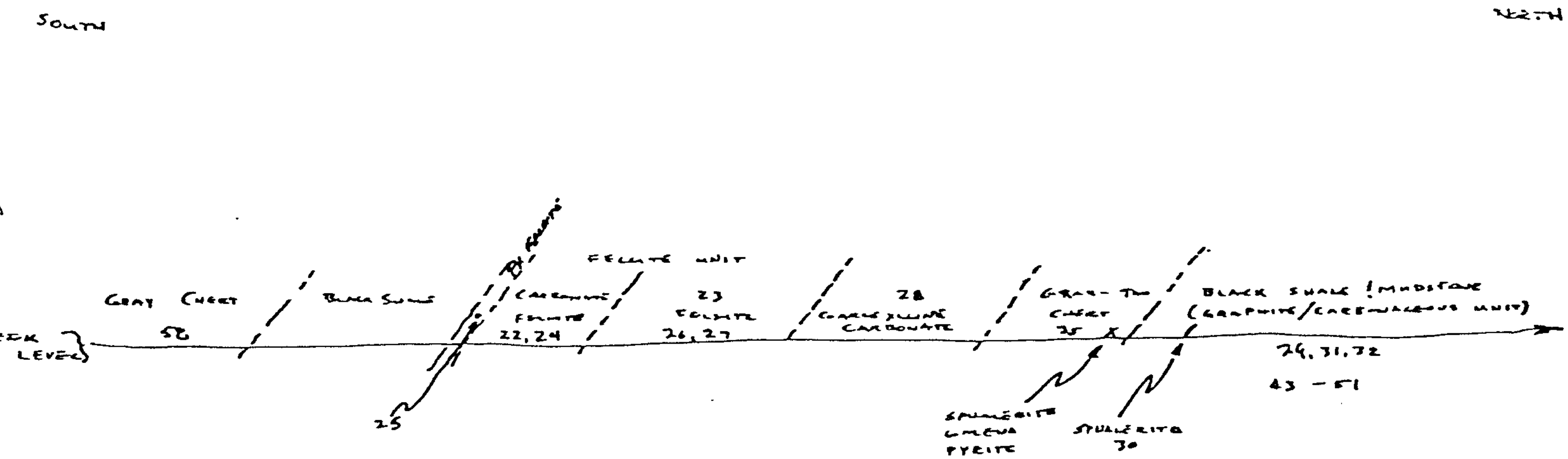
Schematic Stratigraphic Section at Drenchwater Creek Mineralization

Top

Rock Type	Sample Number
Dark gray, siliceous mudstone	
Felsite	77PRUJ 58
Gray Chert	
Dark Gray to Black Chert	
FELSITE UNIT	
Pyritic Felsite	77PRUJ 25
Carbonate Felsite Tuff	77PRUJ 22, 24
Felsite	77PRUJ 23, 26, 27
Coarse Crystaline Limestone	77PRUJ 28
Tan weathering gray chert – mineralized Zn Pb & Py	77PRUJ 35
GRAPHITE / CARBONACEOUS UNIT	
75' Graphitic Mudstone and Shale Unit	77PRUJ 29 - 32
≈2' Sphalerite lens 77PRUJ30	
	77PRUJ 43 - 57

SCHEMATIC GEOLOGIC SECTION AND SAMPLES OF ROCK UNITS, DRENCHWATER CREEK

Howard Pass Quad. NPRA



All samples prefix with: 77PEWJ

FIG BM - 8

WJ 10/77

DRENCHWATER CREEK

HOWARD PASS QUADRANGLE

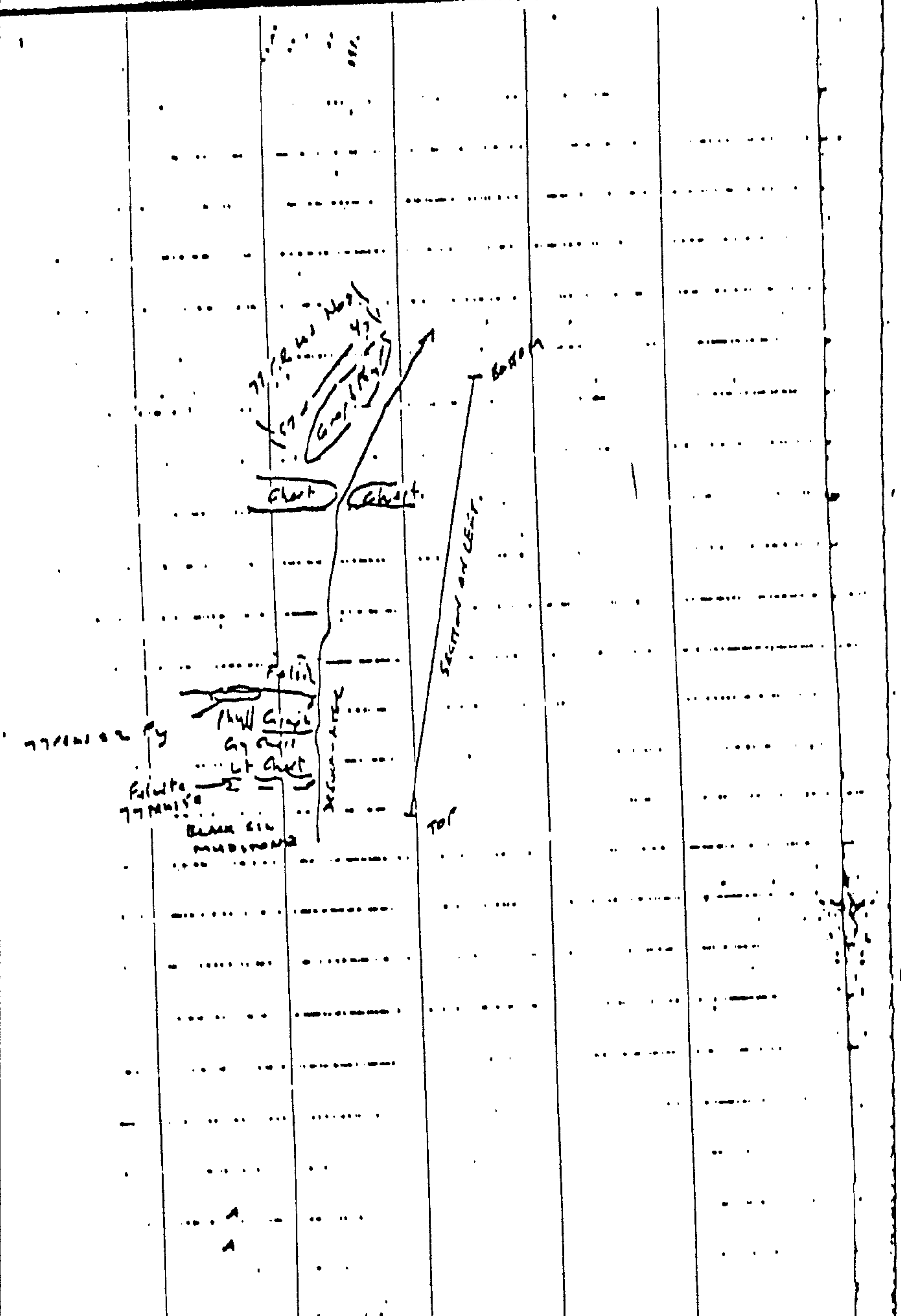


FIG-BM-6

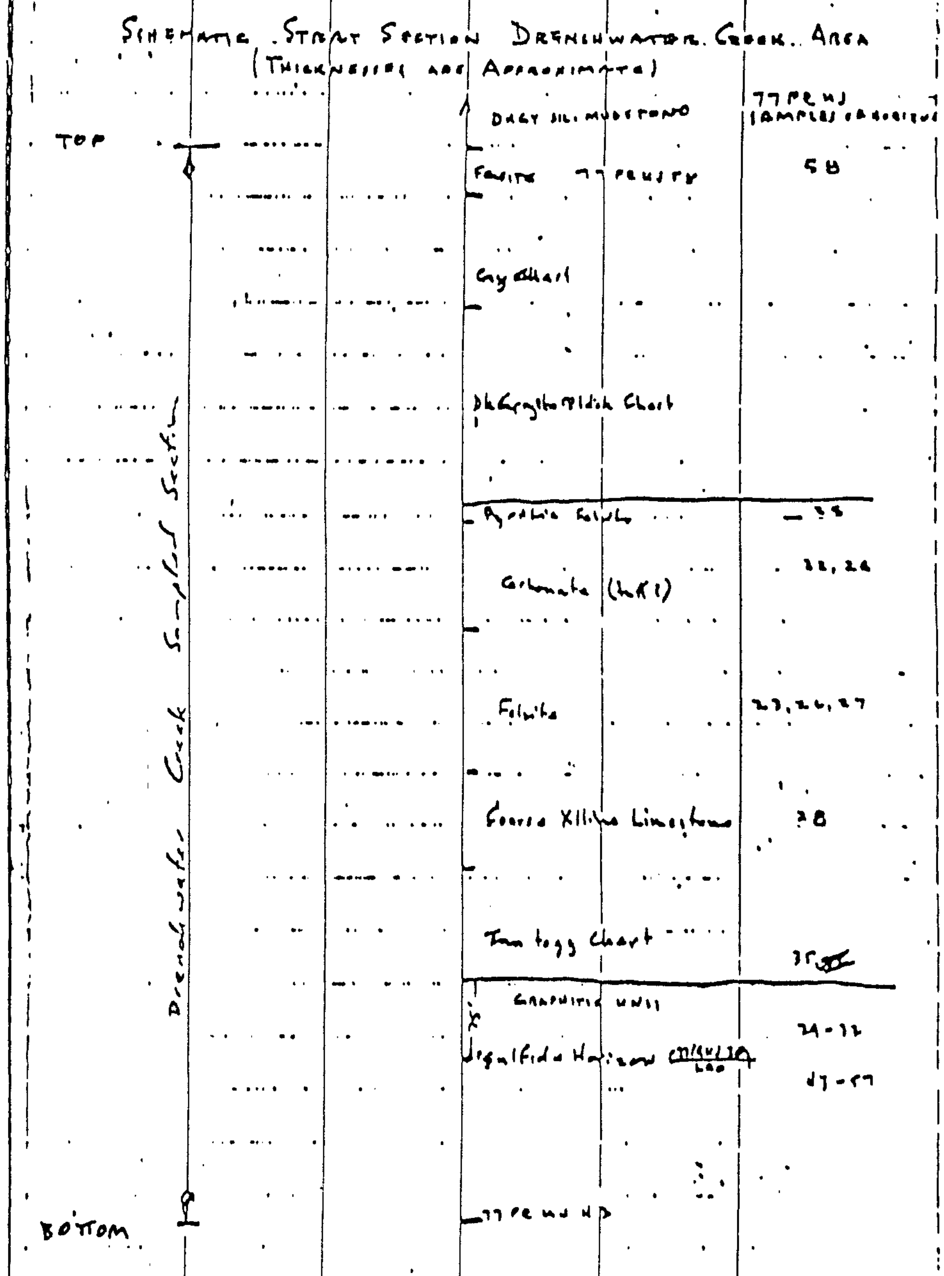
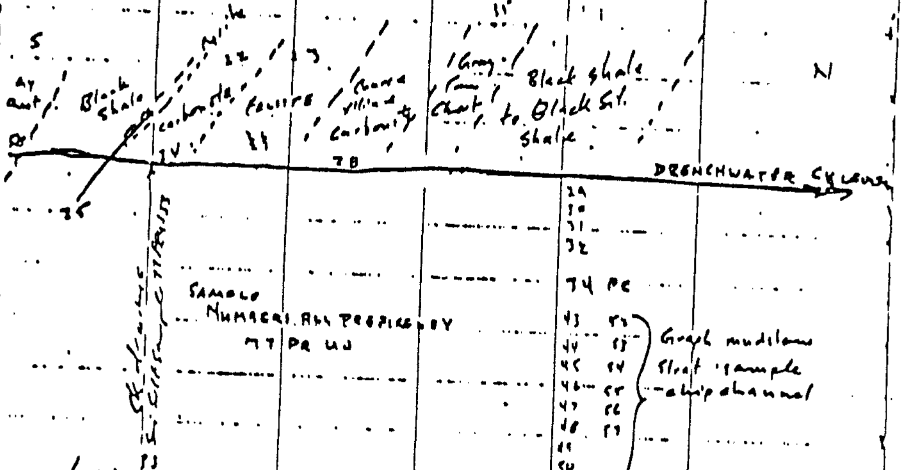


FIG BM-7

DRENCHWATER CREEK

SAMPLE FACE SCHEMATIC



NOTE ... See back of p. 9 for schematic cross section

FIG BM-8

77PRUJ-28 Carbonate tuff (?) coarse gr. resistant to weathering underlies "syncline like" chert bearing rock which lies to south. Minor pyrite. Strike 301° / 55°S.

77PRUJ-29 Black cherty shale below chert unit (which constricts Drenchwater Ck channel.

86' long Chip / Grab sample of face

Pyrite & Sphal bearing.

found 133' "below" contact by I. Tailleur

8/6/77. "Below" = distance paced along hillside.
True strat dist ~75'

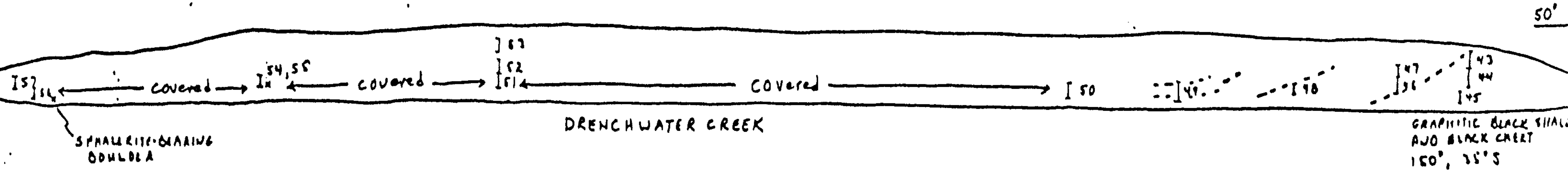
Mineralization not in place

77PRUJ 30 Highgraded sulfide boulder. Total size ~ 1 ft³. No other zones immediately noted. Source and amount present not known.

77PRUJ-31 Black graphitic shale grab sample ~60' N. of area of sulfide bearing float boulder.

DRENCHWATER CREEK BLACK SHALE OUTCROP

6-15-77
BAGGS



SAMPLES 77PRUJ 43 - 57

1" = 40'
Looking West

Dwn: D.W.B

FIG BM-9

TABLE BM-7

Locality: DRENCHWATER CREEK - HOWARD PASS QUADRANGLE

	Elements Analyzed			
Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRUJ 22	55	25	60	Py. grey carbonate tuff(?)
23	20	65	<5	Rhyolite tuff
24	80	95	35	Grey brecciated carbonate
25	70	100	5	Pyrite (~30%) in tuff(?)
25	30	150	20	Grey clastic volcanic with shards
26	5	155	< 5	Pyritic chert
28	5	20	75	Carbonate - tuff
29	5	220	25	Grey siliceous mudstone
30	1,150	105	230,000	Sulphides in black mudstone
31	5	520	80	Grey graphitic shale-mudstone
32	5	150	25	Black carbonaceous mudstone
33	140	720	150	Stream silt
34	85	25	320	Pan conc.; by black shale
35	5	125	5	Banded pyritic chert
36	105	5	75	Grey-black siliceous mudstone
37	100	5	45	Grey chert
38	65	5	45	Light grey mudstone
39	45	5	60	Grey-black pyritic chert

TABLE BM-7 (continued)

Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
	Elements Analyzed			
77 PRUJ 40	55	5	40	Grey chert, some brecciated
41	55	5	45	Dark grey-black chert
42	65	5	65	Grey chert
43	5	125	5	Carbonaceous mudstone-shale
44	5	50	5	Carbonaceous mudstone-shale
45	5	120	10	Carbonaceous mudstone-shale
46	5	125	5	Carbonaceous mudstone-shale
47	5	75	15	Silic. Carbonaceous mudstone-shale
48	5	110	30	Silic. Carbonaceous mudstone-shale
49	5	275	35	Carbonaceous mudstone-shale
50	5	960	40	Carbonaceous mudstone-shale
51	15	1,150	55	Grey silic. mudstone
52	5	435	40	Grey silic. mudstone
53	10	550	20	Black carbonaceous shale
54	5	340	60	Black siliceous mudstone
55	10	360	95	Black siliceous mudstone
56	10	195	50	Black siliceous mudstone
57	15	585	45	Black siliceous mudstone

TABLE BM-7 (continued)

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRDWB 33.1	50	20	105	Black mudstone
34	25	10	625	Black shale
35	55	5	120	Black shale
36	5	35	75	Black mudstone
37	5	40	75	Black mudstone
38	55	50	715	Pyritic ls. conc. in black shale
39	5	80	10	Black shale
40	5	420	50	Black shale
41	< 5	5	< 5	Black siliceous mudstone
42	5	280	5	Fissile black shale
43	< 5	125	< 5	Fissile black shale
44	105	135	250	Stream silt
45	55	355	185	Stream silt
46	30	5	75	Stream silt
47	55	35	70	Stream silt
48	45	180	670	Stream silt
49	10	270	1,000	Stream silt
50	15	565	75	Stream silt
51	40	1,300	180	Stream silt
77 PRUJ 60	65	1,500	47,000	Main sulphide zone
61	80	51,000	110,000	Sulphides in chert
62	5	70	250	Volcanic rock

TABLE BM-7 (continued)

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRUJ 63	5	60	80	Volcanic flow breccia(?)
65	45	1,500	4,100	Boxworks zone
94	< 5	55	10	Volc. agglom. with chert frogs.
95	25	40	160	"Soil"
97	20	50	120	Volcanic rock
98	60	195	130	Stream silt
100	15	55	40	Pyritic volcanic
101	135	20	950	Stream silt
102	5	20	40	Py. ______ grit with chert frogs.
110	40	40	50	Limonite stained volcanic rock
111	30	65	90	Volcaniclastic rock

TABLE BM-8

Locality: DRENCHWATER CREEK - HOWARD PASS QUADRANGLE

Element	Sample Number 77PRUJ-25	Sample Number 77PRUJ-29	Sample Number 77PRUJ-31	Sample Number 77PRUJ-35	Sample Number 77PRUJ-43	Sample Number 77PRUJ-49
Fe	5%	.5%	.3%	1%	.3%	.2%
Ca	.1%	.02%	.5%	.02%	.02%	.03%
Mg	.03%	.03%	.03%	.02%	.05%	.03%
Ag	< 1	1.5	2	1	2	1
As	< 500	< 500	< 500	< 500	< 500	< 500
B	10	10	10	10	10	< 10
Ba	100	200	30	20	200	20
Be	< 2	< 2	< 2	< 2	< 2	< 2
Bi	< 10	< 10	< 10	< 10	< 10	< 10
Cd	< 50	< 50	< 50	< 50	< 50	< 50
Co	5	< 5	< 5	< 5	< 5	< 5
Cr	200	150	100	30	150	150
Cu	30	200	10	7	20	5
Ga	10	< 10	< 10	10	< 10	< 10
Ge	< 20	< 20	< 20	< 20	< 20	< 20
La	100	20	20	100	50	20
Mn	150	10	< 10	10	10	15
Mo	2	7	3	< 2	10	2
Nb	50	< 20	< 20	70	< 20	< 20
Ni	20	15	20	< 5	30	15
Pb	100	100	150	100	70	70
Sb	< 100	< 100	100	< 100	< 100	< 100
Sc	20	< 10	< 10	< 10	< 10	< 10
Sn	< 10	< 10	< 10	< 10	< 10	< 10
Sr	50	< 50	< 50	< 50	< 50	< 50
Ti	3,000	300	200	300	500	100
V	200	50	100	20	150	70
W	< 50	< 50	< 50	< 50	< 50	< 50
Y	15	< 10	< 10	10	< 10	< 10
Zn	< 200	< 200	< 200	< 200	< 200	< 200
Zr	50	20	20	100	30	20

(Values in ppm unless otherwise noted.)

TABLE BM-8 (continued)

Element	Sample Number 77PRUJ-50	Sample Number 77PRUJ-51	Sample Number 77PRUJ-53	Sample Number 77PRUJ-55	Sample Number 77PRUJ-57
Fe	.3%	.3%	1.5%	2%	.5%
Ca	.02%	.05%	.2%	1%	.02%
Mg	.05%	.03%	.07%	.05%	.03%
Ag	3	2	5	2	3
As	< 500	< 500	< 500	< 500	< 500
B	10	< 10	20	10	10
Ba	30	30	200	500	50
Be	< 2	< 2	< 2	< 2	< 2
Bi	< 10	< 10	< 10	< 10	< 10
Cd	< 50	< 50	< 50	< 50	< 50
Co	< 5	< 5	< 5	< 5	< 5
Cr	200	100	150	150	200
Cu	3	15	20	10	30
Ga	< 10	< 10	< 10	< 10	< 10
Ge	20	< 20	< 20	< 20	< 20
La	30	30	50	20	20
Mn	< 10	< 10	< 10	< 10	10
Mo	2	2	10	2	2
Nb	< 20	< 20	< 20	< 20	< 20
Ni	50	5	20	20	15
Pb	200	200	300	150	200
Sb	< 100	< 100	< 100	< 100	< 100
Sc	< 10	< 10	< 10	< 10	< 10
Sn	< 10	< 10	< 10	< 10	< 10
Sr	< 50	< 50	< 50	< 50	< 50
Ti	300	150	500	200	100
V	100	50	100	100	100
W	< 50	< 50	< 50	< 50	< 50
Y	< 10	< 10	< 10	< 10	< 10
Zn	< 200	< 200	< 200	< 200	< 200
Zr	30	20	50	20	< 20

TABLE BM-9

Locality: DRENCHWATER CREEK - HOWARD PASS QUADRANGLE

	Elements Analyzed								
Sample No.	Cu (%)	Pb (%)	Zn (%)	Fe (%)	Ba (%)	Au (ppm)	Ag (ppm)	As (ppm)	Mo (ppm)
Pet. Res. Drenchwater	0.021	8.4	31.0	-	-	-	-	180	22
77 PRUJ 59	0.016	5.9	14.0	2.4	0.02	0.02	160	-	-
59.1	0.018	1.7	18.0	2.2	0.01	0.02	70	-	-
59.2	0.004	4.1	15.0	1.6	0.14	0.02	200	-	-
59.3	0.002	2.1	7.1	0.8	0.23	0.02	42	-	-
59.4	0.002	0.58	21.0	1.7	0.15	0.02	24	-	-
59.5	0.004	1.4	21.0	2.5	0.07	0.02	100	-	-
59.6	0.018	5.2	26.0	3.3	0.04	0.02	190	-	-

TABLE BM-10

Locality: DRENCHWATER CREEK - HOWARD PASS QUADRANGLE

Sample No.	Total Weight of Sample	Volume of 100 Grams of Sample
77 PRUJ 59	6 lbs. 13 oz.	365 ml.
59.1	16 lbs. 15 oz.	350 ml.
59.2	10 lbs. 13 oz.	355 ml.
59.3	11 lbs. 6 oz.	340 ml.
59.4	11 lbs. 2 oz.	340 ml.
59.5	16 lbs. 6 oz.	350 ml.
59.6	13 lbs. 0 oz.	330 ml.

6a. <u>Upper False Wager Creek</u> - Howard Pass Quadrangle

Red and yellow stained cherts in this area were reported by U. S. Geological Survey to be similar in character and age to those associated with the mineralization at the original discovery at Drenchwater Creek. This area is located about 15 miles upstream (south) of the original showing. Samples of pyritic chert, both light and dark gray, were obtained. Outcrop was poor - in that rock was not found in place, but the material is close to being in place, and therefore represents material from near outcrop. The hematite-jarosite "stain" zone is seen to be a surface effect, since by digging one can go through the oxidized (precipitated) material in 4"-6" below the surface, prior to reaching bedrock.

Stream silt samples were taken in this area to determine if any base metal zones are present upstream from this occurrence.

Analytical results are given in Table BM-11.

TABLE BM-11

Locality: FALSE WAGER CREEK - HOWARD PASS QUADRANGLE

	Elements Analyzed			
Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRUJ 103	40	20	70	Fe stained shale
104	5	85	300	Grey siliceous pyrit. mudstone
105	40	75	140	Stream silt, below above rock samples

7. Kiligwa River - Howard Pass Quadrangle

This was the next area to be investigated following the first visit to the main (original) Drenchwater Creek sulfide showing. This is an area of hematite-jarosite (red and yellow) "stained" weathered cherts similar to that found at Drenchwater Creek. The party was still getting oriented in the field and NPRA when this stop was made. The large distance from the Drenchwater Creek showing is a result of bears being present on the ridges immediately to the east of the main sulfide showing.

The field work showed this area to be largely a zone of pyritic chert. The sulfide (pyrite) concretions here were the largest of those seen anywhere, except at Chertchip Creek where the chert constricts the river channel. Several samples were taken here, including stream silts from above the area of chip channel sampling.

The results of these analyses are shown in Tables BM-12, 13.

TABLE BM-12

Locality: KILIGWA RIVER - HOWARD PASS QUADRANGLE

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRDWB 17	125	15	215	Stream silt
18	90	15	300	Stream silt
19	100	20	310	Stream silt
77 PRUJ 36	105	5	75	Grey-black silic. mudstone
37	100	5	45	Grey chert
38	65	5	45	Light grey mudstone
39	45	5	60	Dark grey-black pyrit. chert
40	55	5	40	Light grey chert; brecc. in part
41	55	5	45	Dark grey-black chert
42	65	5	65	Grey chert

TABLE BM-13

Locality: KILIGWA RIVER - HOWARD PASS QUADRANGLE

Element	Sample Number 77PRUJ-36	Sample Number 77PRUJ-39
Fe	2%	3%
Ca	.05%	.1%
Mg	.2%	.15%
Ag	< 1	< 1
As	< 500	< 500
B	30	20
Ba	1,000	1,000
Be	< 2	< 2
Bi	< 10	< 10
Cd	< 50	< 50
Co	< 5	5
Cr	50	150
Cu	100	70
Ga	< 10	< 10
Ge	< 20	< 20
La	30	20
Mn	100	1,000
Mo	< 2	< 2
Nb	20	< 20
Ni	30	50
Pb	10	< 10
Sb	< 100	< 100
Sc	15	10
Sn	< 10	< 10
Sr	50	50
Ti	1,000	500
V	70	30
W	< 50	< 50
Y	15	10
Zn	< 200	< 200
Zr	50	50

(Values in ppm unless otherwise noted.)

8. Boundary Zone - Howard Pass Quadrangle

The informal name for this area comes from its location immediately north of the south NPRA-(d-2) boundary, to the north of Siniktanneyak Mountain (mafic-ultramafic rocks).

Red weathering cherts (Shublik Formation) and a red-stained creek bed were reported by the U. S. Geological Survey (M. Churkin) to be present in this area. A field check in this area showed pyritic cherts, identified as Shublik by the presence of the fossil "Monotis". Two stream silt samples were also taken to analyze for their base metal content. The stream bed contained cobbles of gabbros and peridotite(?).

A conglomerate outcrop to the north of this creek included round gabbroic cobbles. These rocks must have come from the Siniktanneyak mafic-ultramafic pluton to the south.

Analytical results are given in Table BM-14.

TABLE BM-14

Locality: BOUNDARY ZONE - HOWARD PASS QUADRANGLE

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRUJ 66-R	5	40	20	Stream silt, brown stained ck.
66-S	20	20	85	Stream silt
67	70	25	135	Stream silt; main stream

9. Cutaway Creek - Howard Pass Quadrangle

An iron oxide stained zone of possible interest for prospecting was reported by the U. S. Geological Survey. This is a geologic "fenster" where rocks of the Siksikpuk of an upper thrust plate have been eroded, exposing the underlying pyritic cherts of the Shublik Formation.

The Shublik cherts were sampled. While prospecting the pyritic chert some hydrocarbons were detected in the "petrolic" black shales. These latter were sampled also.

Analytical results are given in Table BM-15.

TABLE BM-15

Locality: CUTAWAY CREEK - HOWARD PASS QUADRANGLE

	Elements Analyzed			
Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRDPB 25	55	10	105	Stream silt, red stained ck.
77 PRUJ 78	30	< 5	115	Black chert, Shublik Formation
77 PRDPB 26	-	-	-	Organic - rich shale

10. Lisburne Ridge - Howard Pass Quadrangle

U. S. Geological Survey Professional Paper 302-A describes some phosphate occurrences in the NPRA. A brief visit was made to Lisburne Ridge where fossiliferous carbonates overlie thin interlayered cherts and carbonates (2 inch-3 inch thick beds). No phosphates were found in a cursory examination of the area, although phosphates have been reported to be present on Lisburne Ridge.

11. Mt. Bupto - Howard Pass Quadrangle

Mt. Bupto is referred to as a "boxfold", a dome with steep flanking limbs. A "fist" size sample of fluorite in float material was reported to have been found here by an oil company geologist. Reference to this showing appeared in a U. S. Geological Survey annual report. A brief effort was made to investigate this reported showing. Prospecting of talus float at the base of north-south drainage which cuts Mt. Bupto led to the discovery of minor amounts of green and purple fluorite, with quartz and calcite, cementing brecciated chert and limestone (Lisburne Formation). The brecciation appears to be a result of the formation of the "box" fold. Only trace to minor amounts of fluorite were found.

Once the fluorite was found, prospecting was done up slope to locate the source of the fluorite. No further prospecting was done laterally. In the prospecting up the hill an area of brecciated rocks was found, which may have been the source of the fluorite-bearing rocks on the talus. No fluorite was found in place at this site.

The fluorite is believed to have formed as the result of elemental redistribution and recrystallization during the tectonic activity responsible for brecciation of the limestone and chert. The original carbonate rock represents the source of fluorine (fluoropatite) as well as calcium required for formation of fluorite (CaF_2), which latter was subsequently precipitated in open spaces in the breccia. The fractures observed are on the order of 1/8 inch wide.

One sample was taken representative of the fluorite-cemented breccia. Analysis showed a content of 1.3% fluorine.

12. & 13. Safari Creek I & II - Howard Pass Quadrangle

Two zones, one containing barite nodules weathering out of the Siksikpuk Formation and the other containing dark red weathering rocks of the Kayak Formation, were suggested by the U. S. Geological Survey for possible prospecting. A helicopter reconnaissance of Safari Creek, a previously unnamed tributary to the Kuna River, revealed an extensive zone of dark red residual weathering "pyrite concretions".

Two zones of barite nodules, "lag" deposits weathering out of the Siksikpuk Formation, are present on a ridge. Several of these were collected as specimens.

The Kayak Formation reportedly leaves lag deposits of red pyrite concretions when the enclosing soft black shale is eroded away. One such area was found near the headwaters of Safari Creek. Here the pyrite concretions weather out of the black graphitic Kayak shale. Several of these were sampled and several stream silt samples were taken from drainages cutting the pyrite-bearing shales. Frequently these pyrite concretions contain fossil plant(?) cores.

Analytical results are given in Tables BM-16 and 17.

TABLE BM-16

Locality: SAFARI CREEK - HOWARD PASS QUADRANGLE

Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
	Elements Analyzed			
ZONE I				
77 PRUJ 68	5	< 5	45	Pyrite bands in stromatolite
69	5	30	30	Pyritic chert
70	< 5	15	15	Carb. black shales with pyrite
70.1	5	25	15	Pyrite layer in 77PRUJ70
71	10	45	30	Pyritic chert
72	20	15	125	Pyritic chert
73	25	25	160	Stream silt, below py. samples
74	45	20	155	Stream silt, main drainage
ZONE II				
77 PRUJ 75.1	20	130	255	Pyrite nodules
75.2	15	45	115	Pyrite nodules
76	45	30	380	Stream silt from py. zone, side str.
77	40	25	225	Stream silt from py. zone, main str.

TABLE BM-17

Locality: SAFARI CREEK - HOWARD PASS QUADRANGLE

	Elements Analyzed		
Sample No.	Ba (%)	$BaSO_4$ (%)	Sample Description
77 PRDPB 23	46.	99.5	Nodules
23-A	39.	84.4	Nodules
24	0.035	-	Nodules

14. Siniktanneyak Mountain - Howard Pass Quadrangle

This mafic-ultramafic rock assemblage has had mineral claims staked on it, and several brief exploration sorties have been made into this area in the past. The layered aspect of the gabbro zone is readily observable. The main dunite-peridotite zone, present at the east-southeast zone of the "intrusion" contains chromite. These chromite bands appear to be "layered", while other zones appear to be swirled "lenses". The largest individual band noted was 8 inches thick and 12 feet long.

Only one traverse was made through the chromite-bearing zone. While abundant chromite is present, much of it in small lenses and some in disseminations, no one zone was seen where enough chromite was present to represent a minable situation. The most promising aspect of the chromite potential is that one boulder was noted to contain 8 evenly spaced 4 inch chromite-bearing bands, with minor disseminated chromite between the chromite bands. This represents a concentration of 30% of the total rock being chromite bearing, with a possible Cr_3O_3 content of 44%. However, this was only one boulder. The rubbly nature of the area traversed did not allow observation of the chromite in place. The north-facing cliff was too steep for reconnaissance in a limited fashion. The significant results of our investigation are the recognition of widespread chromite, and cognizance of the layered aspect of the gabbroic phase of the intrusion.

Regional geologic work suggests that the rock sequences are the inverse of those expected in a classic mafic-ultramafic layered intrusion. The presently accepted interpretation is that the

Siniktanneyak and the other mafic-ultramafic units in the Brooks Range were thrust into their present locales from areas located as far as 120 miles to the south. This thinking is the outgrowth of many years of fieldwork. Furthermore, these intrusions are thought to be "alpine" type. However, initial field investigation of the Siniktanneyak area does not compel one to discount the possibility that this sequence may be representative, at least in part, of a layered intrusion.

Detailed field, petrographic work is required to solve this problem, which has important implications regarding the potential for significant associated mineralization in these rocks.

Analytical results are given in Tables BM-18 and 19.

TABLE BM-18

Locality: SINIKTANNEYAK MOUNTAIN - HOWARD PASS QUADRANGLE

Sample No.	Elements Analyzed Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
N.W. PYRITIC ZONE				
77 PRUJ 80	160	5	5	Felsite with pyrite
81	40	5	30	Felsite with pyrite
84	10	5	20	Felsite with pyrite
85	10	20	225	Felsite with pyrite
86	10	5	15	Felsite with pyrite

TABLE BM-19

Locality: SINIKTANNEYAK MOUNTAIN - HOWARD PASS QUADRANGLE

Sample No.	Cr (ppm)	Cu (ppm)	Mo (ppm)	Pb (ppm)	As (ppm)	Zn (ppm)	Sample Description
	Elements Analyzed						
"Sinik. Mtn."	18,000	0.002	2	0.05	10	0.21	Random dunite sample, with approx. 3% chromite
77 PRUJ Cr	21,000	($\cong$ 39-46% chromite, or $\cong$ 31% Cr_2O_3)					High grade 6 inch band of chromite

15. <u>Spike Creek</u> - Misheguk Mountain Quadrangle

Red-weathering pyritic cherts, located about 6 miles from the Kagvik site were field checked on the recommendation of C. Mayfield of the U. S. Geological Survey.

A brief visit was made to this locality, and the pyritic chert was sampled. The stratigraphic section in the area appears to be remarkably like that at the Red Dog prospect - with the exception of the presence of the sulfide bearing unit.

The position of this unit within the thrust and stratigraphic sequence remains to be defined.

One sample of pyritic gray chert was taken for chemical analysis; the results are given in Table BM-20.

TABLE BM-20

Locality: SPIKE CREEK - MISHEGUK MOUNTAIN QUADRANGLE

Element	Sample Number 77PRUJ114
Fe	1%
Ca	.1%
Mg	.2%
Ag	< 1
As	< 500
B	20
Ba	2,000
Be	< 2
Bi	<10
Cd	<50
Co	< 5
Cr	10
Cu	15
Ga	<10
Ge	< 20
La	20
Mn	50
Mo	< 2
Nb	< 20
Ni	10
Pb	10
Sb	<100
Sc	< 10
Sn	< 10
Sr	50
Ti	500
V	20
W	< 50
Y	< 10
Zn	<200
Zr	20

(Values in ppm unless otherwise noted.)

16. <u>Utukok-Kokolik River Coal</u> - Misheguk Mountain Quadrangle
&
17. Thin coal beds in the upper Utukok and Kokolik Rivers are reported in U. S. Geological Survey Professional Paper 303C. A one hour helicopter reconnaissance of the Upper Utukok and Kokolik Rivers was performed to see if sufficient coal exposures were present to warrant a detailed surface sampling program. The areas sampled were north from the Driftwood airstrip to the valley north of the Archimedes Ridge. No readily visible coal beds were noted from the air. Only one field check was made, however, and here the rocks were a dark gray shale rather than coal.

No further investigation was made of the coal potential of NPRA.

18. Rolling Pin Creek - Howard Pass Quadrangle

A color anomaly, located west of the main Drenchwater Creek area, was sampled and analyzed for its base metal content. The color anomalies were caused by the oxidation of pyrite in gray chert. Some pyrite was noted to be cementing breccia fragments. Lag deposits of small barite nodules suggest this to be the Siksikpuk Formation.

Analytical results are given in Table BM-21.

TABLE BM-21

Locality: ROLLING PIN CREEK - HOWARD PASS QUADRANGLE

Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Sample Description
77 PRUJ 109	50	5	25	Pyritic chert

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